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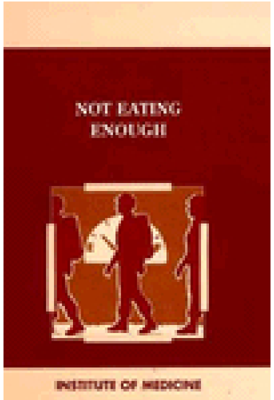


# Not Eating Enough: Overcoming Underconsumption of Military Operational Rations

Bernadette M. Marriott, Editor; Committee on Military Nutrition Research, Institute of Medicine

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# Not Eating Enough

## Overcoming Underconsumption of Military Operational Rations

Committee on Military Nutrition Research
Food and Nutrition Board
Institute of Medicine

Bernadette M. Marriott, Editor

National Academy Press
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The serpent has been a symbol of long life, healing, and knowledge among almost all cultures and religions since the beginning of recorded history. The image adopted as a logotype by the Institute of Medicine is based on a relief carving from ancient Greece, now held by the Staatlichemuseen in Berlin.

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# Preface

This publication, *Not Eating Enough, Overcoming Underconsumption of Military Operational Rations*, is another in a series of reports based on workshops sponsored by the Committee on Military Nutrition Research (CMNR) of the Food and Nutrition Board (FNB), Institute of Medicine, National Academy of Sciences. Other workshops or symposia have included such topics as food components to enhance performance, nutritional needs in hot environments, body composition and physical performance, nutrition and physical performance, cognitive testing methodology, and fluid replacement and heat stress. These workshops form a part of the response that the CMNR provides to the Commander, U.S. Army Medical Research and Materiel Command (USAMRMC), regarding issues brought to the committee through the Military Nutrition Division of the U.S. Army Research Institute of Environmental Medicine (USARIEM) at Natick, Massachusetts.

## FOCUS OF THE REPORT

Eating enough food and thereby meeting nutritional needs to maintain good health and perform well in all aspects of life—both on the job and during

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relaxation—is important for all individuals throughout their lives. Food is provided for military personnel on the military bases through garrison dining facilities and during field operations through a variety of military operational rations. In garrison, soldiers can choose to eat in the military dining halls, eat at home with their families, or eat in restaurants similar to the American civilian population. In the field, food selection is limited to the operational ration available during the mission. The nutrient level in military food—whether offered in military dining halls or packaged in military operational rations—is guided by the joint Tri-Services Regulation, AR 40-25 (1985). This regulation includes nutritional allowances and standards for active military personnel (the Military Recommended Dietary Allowances [MRDAs]), nutrient standards for operational and restricted rations (for example, survival rations), military menu guidance, and a chapter on nutrition education. The MRDAs are based on the Recommended Dietary Allowances (RDAs) developed by the FNB to provide for the basic nutritional needs of all healthy Americans (NRC, 1989). The military operational rations are thus designed to provide a healthy diet for military personnel that includes additional energy and nutrients as may be needed to perform heavy work or meet the demands of environmental extremes.

Unfortunately, in training and field operations, military personnel often do not eat their rations in amounts adequate to meet energy expenditures. Consequently, they lose weight and potentially risk loss of effectiveness both in physical and cognitive performance. The U.S. Army's concern about potential performance degradation has led to a consideration of the cause of this underconsumption in the field. Why do soldiers eat less and lose weight in the field? Can the drop in food intake be linked to stress in the field setting, the food itself, or the eating situation? Is the underconsumption serious enough to affect performance? The CMNR was asked to assist a collaborative program between scientists at USARIEM and the U.S. Army Natick Research, Development and Engineering Center (NRDEC) by reviewing recent research in military settings that addresses these issues, coupled with more general research on the effects of the following on food intake: physiology (hydrations status, biological rhythms), the food itself (quality, quantity, variety, learned preferences, food expectations), food packaging and marketing, and social factors (the eating situation, food appropriateness, social facilitation and inhibition). The purpose was to (1) evaluate whether the consistent energy deficit recorded in military personnel in field settings could significantly affect performance and (2) discuss potential strategies that could be used by the military to reduce underconsumption. The CMNR was asked to consider the results from military research and from the other studies and also to address five questions posed by the Army about soldier underconsumption. The questions that were posed to the committee are included in Chapter 1 of this report.

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The views of military and nonmilitary scientists from the fields of food science, food marketing, food engineering, nutrition, physiology, various medical specialties, and psychology on the most recent research concerning factors that influence food intake in stressful conditions are included in this report. Although described within a context of military tasks, the conclusions and recommendations presented in Chapters 1 and 2 of this report have wide-reaching implications for individuals who find that job stress changes their eating habits.

## HISTORY OF THE COMMITTEE

The CMNR was established in October 1982 following a request by the Assistant Surgeon General of the Army that the FNB of the National Academy of Sciences set up a committee to advise the U.S. Department of Defense on the need for and conduct of nutrition research and related issues. The committee's tasks are to identify nutritional factors that may critically influence the physical and mental performance of military personnel under all environmental extremes, to identify deficiencies in the existing data base, to recommend research that would remedy these deficiencies and approaches for studying the relationship of diet to physical and mental performance, and to review and advise on standards for military feeding systems. Within this context, the CMNR was asked to focus on nutrient requirements for performance during combat missions rather than requirements for military personnel in garrison (the latter were judged to be not significantly different from those of the civilian population). Although the membership of the committee has changed periodically, the disciplines represented have consistently included human nutrition, nutritional biochemistry, performance physiology, food science, and psychology. For issues that require broader expertise than exists within the committee, the CMNR has convened workshops. These workshops provide additional state-of-the-art scientific information and informed opinion for the consideration of the committee.

## COMMITTEE TASK AND PROCEDURES

In March 1993, personnel from the USARIEM requested that the CMNR review research conducted by the U.S. Army and examine the current state of knowledge concerning the consistent underconsumption of military operational rations. This request originated from joint concerns of scientists at the NRDEC, who developed food products and tested their acceptability, and scientists in the Division of Nutrition at USARIEM. It also arose from a Science and Technology Objective (STO) to prevent performance degradation of the soldier under the stress of sustained field operations as part of an overall

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initiative, "The Soldier as a System." This initiative recognizes the importance of all aspects of the soldier's equipment and person for enhanced capabilities necessary for the future (Army Science Board, 1991).

The committee was aware of the complexity of the issue, in particular the question of when a reduction in intake of rations becomes detrimental and can be labeled underconsumption, and at what point undernutrition leads to a decrement in performance. The CMNR decided that the best way to review the state of knowledge in this disparate area was through a workshop at which knowledgeable researchers could review published research with the committee. Such a workshop would enable the CMNR to review the adequacy of the current research and to identify gaps in the knowledge base that might be filled by future research.

A subgroup of the committee met in April 1993, with assistance from Herbert L. Meiselman from NRDEC, to determine the key topics for review, to identify speakers with expertise in these topics, and to plan the workshop for November 1993. Invited speakers were asked to prepare a review paper on their assigned topic for presentation and publication and to make specific recommendations in response to several questions posed to them prior to the workshop. The CMNR also believed that it would be beneficial to include a review of earlier and ongoing military research. Scientists at USARIEM and NRDEC participated in the workshop, which resulted in a well-rounded agenda. At the workshop, each speaker gave a formal presentation, which was followed by questions and a brief discussion period. The proceedings were tape recorded and professionally transcribed. At the end of the presentations, a general discussion of the overall topic was held. Immediately after the workshop, the CMNR met in executive session to review the issues, draw some tentative conclusions, and assign the preparation of draft reviews and summaries specific topics to individual committee members. Committee members subsequently met in a series of working sessions and worked separately and together using the authored papers and additional reference material to draft the summary and recommendations. The final report was reviewed and approved by the entire committee.

The summary and recommendations of the Committee on Military Nutrition Research constitute Part I of this volume, and Parts II through V include the papers presented at the workshop. Part I has been reviewed anonymously by an outside group with expertise in the topic area and experience in military issues. The authored papers in Parts II through V appear in the order in which they were presented at the workshop. These chapters have undergone limited editorial change, have not been reviewed by the outside group, and represent the views of the individual authors. Selected questions directed toward the speakers and the speakers' responses are included when they provided a flavor of the workshop discussion. This is followed by brief biographical sketches of committee members and chapter authors in Appendix A and a list of abbreviations used in this report in

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Appendix B. The invited speakers were also requested to submit a brief list of selected background papers prior to the workshop. These recommended readings, relevant citations collected by CMNR staff prior to the workshop, and selected citations from each chapter are included in the Selected Bibliography (Appendix C).


## ACKNOWLEDGMENTS

It is my pleasure as chairman of the CMNR to acknowledge the contributions of the FNB staff, particularly the excellent technical and organizational skills of Bernadette Marriott, Ph.D., associate director of the FNB and the program director for the CMNR. Her assistance in organizing the workshop and her persistence in getting the cooperation of the speakers and the committee in order to produce a timely publication is commendable and greatly appreciated. I wish to acknowledge as well the excellent contributions by the workshop speakers and their commitment to participating and preparing detailed review papers on relatively short notice. The CMNR appreciates the assistance of Herbert L. Meiselmen and F. Matthew Kramer from NRDEC and of COL Eldon W. Askew and LTC Mary Z. Mays from USARIEM for their assistance in identifying issues of concern to the military and obtaining the involvement of the military personnel who participated in the workshop, which was held in the auditorium at the Natick Laboratory, Natick, Massachusetts. The committee expresses their appreciation to the commanders at NRDEC and USARIEM for making their superb conference facility available for this workshop. The CMNR also is appreciative of the support provided by Cliff Murphy and Veronica Panciocco, who were instrumental in making the local arrangements at Natick. The committee is grateful to Ms. Panciocco for her continued support in providing information and assistance with all aspects of CMNR.

I want to especially acknowledge the excellent participation of the members of the discussion panel, Robert E. Smith, Howard Moskowitz, Cheryl Achterberg, and Robin B. Kanarek, for taking time from their very busy schedules to listen to the proceedings and to provide insightful comments that helped form the discussion and recommendations of this workshop. The critiques by the anonymous reviewers and by FNB liaison member Johanna T. Dwyer provided helpful insight in the development of this final document. The editorial efforts of Judy Grumstrup-Scott and the assistance of research assistants Valerie Breen and Susan Knasiak are gratefully acknowledged. The effort of Donna Allen, CMNR project assistant, in word processing and preparing the camera-ready copy for this report is greatly appreciated.

Finally, I am grateful to the members of the committee who participated significantly in the discussions at the workshop and in the preparation of the summaries of the proceedings. The commitment of committee members, who


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serve without compensation, to evaluating the information presented and developing recommendations for consideration by the military is commendable. I am personally inspired as I work with this group of dedicated professionals.

ROBERT O. NESHEIM, Chair

Committee on Military Nutrition Research

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# Part I

# Committee Summary and Recommendations

PART I OUTLINES THE TASK presented to the Committee on Military Nutrition Research (CMNR) by scientists at the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Natick Research, Development and Engineering Center (NRDEC): to evaluate the data on and problem of underconsumption of military operational rations and recommend strategies for overcoming this underconsumption. As part of the charge to the CMNR, the Army posed the following five questions:

1. Why do soldiers underconsume (not meet energy expenditure needs) in field operations?
2. What factors influence underconsumption in field operations? Identify the relative importance of rations, environment, the eating situation, and the individual.
3. At what level of consumption is there a negative impact on physical or cognitive performance?
4. Given the environment of military operations, what steps are suggested to enhance ration consumption? To overcome deficits in food intake? To overcome any degradation in physical or cognitive performance?
5. What further research needs to be done in these areas?

In Chapter 1, the committee reviews the data on deficits in energy intake and its relation to reductions in soldiers' physical and cognitive performance by using relevant background materials, data from controlled field studies, and

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the workshop proceedings from November 3–4, 1993. The committee begins by defining the terms used in the report and proceeds with a review of factors that lead to reduced energy intake, the potential effect on performance, and possible solutions to overcome underconsumption. The committee views underconsumption as a particular problem for rapidly redeployed troops who have lost 5 to 10 percent of their body weight without the opportunity to regain it. For the physically fit soldier with low body fat, less fat loss and more reduction in lean body mass will accompany continued weight loss, thereby increasing the risk for reduced performance capacity.

The CMNR answers the questions posed by the Army in Chapter 2 before presenting their conclusions, recommendations, and suggestions for future research. In concluding that soldiers' energy intakes must match their energy expenditures, the committee acknowledges the multiple logistical, situational, and sensory factors that contribute to underconsumption in field operations. To enhance consumption of military operational rations, the CMNR concludes that steps need to be taken to enhance rations, to make specific time available for eating, and to cope with the factors that detract from ration acceptance. The CMNR recommends the establishment of a *field feeding doctrine* to parallel the water doctrine that is already in place. In addition to the field feeding doctrine, the CMNR further recommends keeping soldiers well-hydrated to avoid hypohydration-induced anorexia, enhancing the MRE to improve consumption, educating commanders about the relationship between ration intake and performance, introducing snacks to increase energy intake, and developing promotional materials for the information of commanders and soldiers alike. Guidance is also provided regarding the rate of weight loss and the potential for performance decrements.

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# 1

# Introduction and Background

The Committee on Military Nutrition Research (CMNR) has reviewed many studies over the past 10 years that evaluated the acceptance and intake of military food items as part of its continuing task of assessing the nutritional adequacy of military operational rations (see IOM, 1992a for summary). The current main operational ration, the Meal, Ready-to-Eat (MRE), was developed in 1981 as the primary ration to replace the C Ration, which had been the mainstay of operational rations for many years. The MRE is compact, has a long shelf life, and can be issued directly to the individual soldier. It can be eaten with or without heating, and the 3,600 kcal provided by the total ration was designed to meet the Military Recommended Dietary Allowances (MRDAs) (see AR 40-25, 1985) for all nutrients. The MRE was initially developed for use up to 3 days at the start of military operations until other field feeding systems became available. The simplicity of this system, logistically and in terms of reduced need for food preparation personnel, led to the desire to use this ration for extended periods of time (i.e., 10 to 30 days). Field testing was thus ordered to evaluate the effectiveness of the MRE over extended periods of time. Summaries of these field studies can be found in Chapters 6 through 10 of this volume.

The CMNR reviewed many of these studies when they were initially completed and noticed that underconsumption of the ration appeared to be a

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consistent problem. Typically, soldiers did not consume sufficient calories to meet energy expenditure and consequently lost body weight. The energy deficit has been in the range of 700 to 1,000 kcal/d and thus raises concern about the influence of such a deficit on physical and cognitive performance, particularly over a period of extended use. Anecdotal reports from Operation Desert Storm, for example, indicated that some units may have used MREs as their sole source of food for 50 to 60 days—far longer than the original intent when the MRE was initially field tested. In contrast, studies with special purpose subsistence rations that supplied limited energy (1,500–2,000 kcal), but were based on similar design of the MRE, reported that the rations were fully consumed, and soldier weight losses were experienced as would be predicted by the limited calories in the rations. Systematic records of personnel weight loss and nutritional status were not maintained during the combat situation of Desert Storm. There were, however, no apparent major nutritional problems associated with this long-term use of MREs. Based on continuing research with the MREs as described later in this chapter and in Chapters 6 through 10 of this report, the Army Surgeon General, with concurrence from the Air Force, Marine Corps, and Navy, has recently issued a revised policy statement that "…allows the MREs to be consumed as the sole source of subsistence for up to twenty-one days" (U.S. Department of the Army, 1995).

There have been successive modifications of the MRE since 1981. These modifications in type of food items, diversity of meals, packaging, and food quality have produced small improvements in total consumption but have not significantly reduced the energy deficit that occurs when MREs are consumed. This problem continues in spite of positive hedonic ratings of the MRE ration items in laboratory and field tests. The suboptimal intake of operational rations thus remains a major issue that needs to be evaluated.

This report originated from a concern within the military about the consistency of the deficit in energy intake and whether such a decrement could lead to meaningful reductions in physical and/or cognitive performance of troops during military operations. The report focuses on the various factors that may contribute to the reduced intake of operational rations, the potential effect on soldier performance, and suggested steps that may be taken to overcome the problem. The data covered in this report are limited to controlled field studies of operational rations. The information and conclusions drawn from these data, while reflecting the military performance demands in rigorous field conditions and environmental extremes, do not, however, reflect the extreme physical, social, and psychological stress of combat.

## THE COMMITTEE'S TASK

The CMNR of the Food and Nutrition Board (FNB), Institute of Medicine, National Academy of Sciences, was asked to assist in a collaborative program

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between scientists in the Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM), and the U.S. Army Natick Research, Development and Engineering Center (NRDEC) to strategies on how to overcome underconsumption of military operational rations. The CMNR's task was to review the data on ration intake in controlled field settings, to determine whether the consistently reported suboptimal energy intake could be termed *underconsumption* , to evaluate whether this lowered intake could be detrimental to performance, and to discuss strategies that might be effective for increasing ration consumption. The committee was thus charged with reviewing the existing data on ration intake from studies that had been conducted by the Army and integrating current scientific hypothesis with relevant data on factors that depress or, conversely, enhance food intake. Other than anecdotal information, data were not presented on ration intake from soldiers engaged in combat situations.

The committee was also asked to address five questions that dealt with the concept of underconsumption as it related to military applications. These questions are listed in Table 1-1.

The basic factors and viewpoints of key scientists from USARIEM and NRDEC related to soldier underconsumption were initially discussed with the chair and several members of the CMNR in a small planning session in March, 1993. At this meeting the CMNR indicated their recognition of the complexity of the issues and decided to convene a workshop that would provide more specific information about the military research coupled with relevant presentations from scientists from academic and industry settings. In particular the committee members indicated the workshop scope should include more specific information about (1) Army field feeding logistics; (2) new developments

TABLE 1-1 Questions to be Addressed in This Report

1. Why do soldiers underconsume (not meet energy expenditure needs) in field operations?
2. What factors influence underconsumption in field operations? Identify the relative importance of
   - rations,
   - environment,
   - eating situation, and
   - the individual.
3. At what level of underconsumption is there a negative impact on physical or cognitive performance?
4. Given the environment of military operations, what steps are suggested to enhance ration consumption? To overcome deficits in food intake? To overcome any degradation in physical or cognitive performance?
5. What further research needs to be done in these areas?

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in operational rations; (3) an overview of Army research on food intake patterns and factors affecting food intake; (4) recent Army research results on the impact of lowered energy intake on performance; and (5) expert reviews of physiological, psychological, and social factors that influence eating.

The workshop therefore was convened on November 3–4, 1993 to assist the CMNR in responding to the Army and provide background information useful for developing its report. This workshop included presentations from military and nonmilitary scientists with expertise in food engineering, food marketing strategies, food science, nutrition, nutritional biochemistry, physiology, psychology, and social factors. A panel discussion was held at the end of the workshop to summarize the findings and discuss potential strategies to increase ration intake. The four invited panelists contributed their expertise in complex data analysis, food development, ingestive behavior, and nutrition education. The panel discussion, summary statements, and recommendations were important contributions to the committee deliberations and conclusions. The invited speakers discussed their presentations with committee members at the workshop and submitted the contents of their verbal presentations as written reports. The committee met after the workshop to discuss the issues raised and the information provided. The CMNR later reviewed the written reports and drew on its collective expertise and the scientific literature to develop the summary, conclusions, and recommendations that appear here and in Chapter 2.

### Terms Used in This Report

The term *underconsumption* will be used in Part I of this report to represent food intake that has been documented to provide fewer calories than required by energy expenditure on an individual or group basis. Use of the term underconsumption in this manner thereby assumes a longer-term risk of undernutrition if it persists over an extended period of time.

In the military sense, a *ration* is the nutritionally adequate food allotment for one person for one day; a military operational *meal* is a unit making up one-third of the daily nutritional requirement of a ration. An *operational ration* is a collective term for rations used in the field or in combat. For operational rations the choice of a specific ration or meal type for individual or group feeding is determined by the tactical and logistical characteristics of the feeding situation, or Mission, Enemy, Troops, Terrain, and Time (METT-T) dependent (Mason et al., 1982; NLABS, 1983). Throughout Part I the committee uses the term *ration* collectively to represent the five types of current military operational rations (Meal, Ready-to-Eat [MRE], T, B, and A Rations, and the Unitized Group Ration [UGR]). The ration types are described

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briefly here and in detail by Gerald A. Darsch and Philip Brandler in Chapter 7.

The *Meal, Ready-to-Eat (MRE)* is an operational ration currently configured as 12 menus with all 12 menus packaged together in a case. Each meal weighs 11/2 pounds (0.7 kg) and comprises six to eight components. The individual meal is packaged in retort[1] pouches, and entrees include chicken stew, pork with rice, and spaghetti, with accompaniments of fruit, cookies, cheese crackers, a beverage, and seasonings. Individual meals are nutritionally balanced in accordance with the Office of the Surgeon General's (OTSG) requirements as stated in U.S. Army Regulation 40-25 (1985). The MRE is a general purpose ration that is intended to be carried and consumed in the field in conflict situations where cooks cannot prepare group meals by virtue of the tactical environment. Since 1983, the MREs have been improved continually based on surveys of troop feedback from the field, including early feedback from Operation Desert Shield/Storm; from focus groups; and from individual interviews with soldiers.

The *Tray Ration (T Ration)* is composed of heat-and-serve prepared foods in half-size steam-table (1.66 cubic ft) metal containers, with all necessary components, including napkins, knives, forks, trays, and so on, contained in modules. Each meal is nutritionally balanced in accordance with Army Regulation 40-25 (1985) and includes an entree, a vegetable, a starch, and a dessert. The T Ration provides a 10-d breakfast and a 10-d lunch-dinner menu for 18 military personnel. The most tactically versatile of the group rations, the T Ration provides hot group meals with limited personnel and minimal equipment. The T Ration has been the subject of a product improvement program at NRDEC, and menus have been restructured on a continuous basis to eliminate less acceptable items and to add new, more highly acceptable items.

The *B Ration* is a cook-prepared group meal that requires a field kitchen. All ingredients used to prepare the B Ration are semi-perishable, and therefore, no refrigeration is required. Most of these semi-perishable ingredients are standard institutional-type ingredients such as flour, sugar, and large (# 10) cans of vegetables and meats. In addition, there are 13 unique items that are either dehydrated or chunked and formed. Preparation of these meals in the field using field kitchens is a demanding task that requires considerable culinary skill. The B Ration provides a 10-d breakfast and dinner menu.

The *A Ration* is a meal prepared by cooks in a field kitchen where refrigeration is available, and chilled and frozen products can be provided.

[1] In retort processing, packaged foods are heat treated (at approximately 250¹F) under pressure for sufficient time to inactivate food microorganisms. Examples of foods that require retort processing include low acid foods with sufficient moisture to support the growth of microorganisms (e.g., entrees, vegetables, starches, and desserts).

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Like the B Ration, this meal requires considerable cooking skill and demands careful inventory management because of both the perishable nature of some ingredients and the total number and quantity of ingredients necessary to prepare and serve meals. The A Ration provides a 10-d breakfast and dinner menu.

The *Unitized Group Ration (UGR)* integrates into a unified system the A Ration minus the perishables, the B Ration, the T Ration, and additional brand-name items that can be quickly prepared. The UGR contains 15 breakfast menu options (5 each of rations A, B, and T) and 30 lunch-dinner menu options (10 each of rations A, B, and T). Each of the meal options is unitized in six containers and provides all of the ingredients, trays, utensils, napkins, condiments, and so on, necessary to feed 100 military personnel. The six containers make up one layer of a pallet, and four layers constitute a pallet load. This system maximizes the efficiency of group feeding in the field and reduces the number of line items a cook must order for a meal to one-tenth the number formerly required. The UGR has been developed recently and is currently under final review.

### Definition of the Problem and Report Organization

To develop answers to the questions posed by the Army, the CMNR sought to identify the magnitude of the lowered consumption experienced by troops in field settings, whether and when the energy deficit affected performance of militarily relevant tasks, and the specific factors involved. In this chapter, initially the committee reviewed the research evidence related to underconsumption and performance. In addressing the data with the assistance of personnel from USARIEM and NRDEC, the committee determined that the situational factors of the eating environment and attributes of the food were the major elements involved in reduced consumption. A review of research findings in these general areas is then presented in the sections that follow with an overview of newly proposed plans for changes of military operational rations and field feeding programs. The CMNR concludes its research synopsis with a discussion of the potential impact of these proposed changes on the underconsumption problem and incorporates a discussion of alternative research and operational strategies suggested at the workshop.

## LOWERED INTAKE AND PERFORMANCE

### Overview of Energy Intakes During Military Exercise

Problems of suboptimal consumption during military exercise in real-life situations have been studied by the Military Nutrition Division at USARIEM

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(see Baker-Fulco, Chapter 8 in this volume). Either food records or, for group feeding situations, visual estimation techniques are used to estimate soldier intakes for from 5 to 30 days. Preweighed or prepackaged rations are used for much of the food in the field. Studies have been done of military groups in garrison dining facilities in normal and training environments to obtain comparative data on energy intake. See Table 1-2 for a summary.

Typical energy intakes of military men in garrison situations range from 2,730 to 3,260 kcal/d. When soldiers are actively involved in training, garrison intakes range from 3,200 to 4,650 kcal/d. In field training operations male soldiers had significantly lower intakes, ranging from 2,265 kcal in a study in Bolivia where the MRE and B Rations were fed to individuals in a high-altitude environment (Edwards et al., 1991), to a high of 3,713 kcal at Fort Sill where A Rations were provided three times a day in the field as hot meals at regularly scheduled times (Rose and Carlson, 1986). The Fort Sill study was considered to represent the optimal situation for feeding soldiers in field operations. In another study at Fort Chaffee, a control group received hot meals in a fixed dining facility while the MRE group received the rations in their barracks at scheduled meal times in a thermally neutral environment (C. D. Thomas et al., U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data). There was weight loss in both groups, but the MRE group lost twice as much weight over 30 days (4.8 percent of body weight versus 2.4 percent in the control group), with a difference in energy intake of about 400 kcal/d. These estimates of deficits have been confirmed in studies of energy expenditure in the field using the doubly labeled water technique, which show a typical daily deficit of 500 to 2,000 kcal (see Chapters 8 and 14).

In a recent study of women in a hot environment at Fort Hood, Texas, that provided two B Rations and one MRE per day, the average intake was 2,343 kcal/d, which is close to the MRDA of 2,400 kcal (Rose, 1989). The women in this study maintained their body weight; however, they had liberal access to commercial snack foods. In previous studies in garrison during training, women had similar intakes ranging from 2,314 to 2,592 kcal/d, as compared to nontraining garrison intakes of 1,832 kcal/d (see Baker-Fulco, Chapter 8 in this volume for summary). In the Bolivia study mentioned above (Edwards et al., 1991), the women demonstrated a marked decrease in intake similar to that seen in men at high altitudes with an average intake of only 1,668 kcal/d.

In studies conducted in cold weather, energy intakes are found to be much higher, demonstrating the effect of the increased energy requirement in cold-weather exercises. However, the increased level of intake does not offset the increased level of expenditure, as verified by studies conducted in the cold in which doubly labeled water was used to estimate actual energy expenditure (see Baker-Fulco, Chapter 8 in this volume).

Many contributing factors such as the ration itself, meal schedules, environment, military and unit command emphasis, military feeding policy,

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and individual biological rhythms may be important contributors to underconsumption. Food waste in the field is considerable, with 1,000 to 3,000 kcal/d differences occurring when actual intake of rations is monitored (only 51–78 percent of the ration being eaten). Soldiers, if given the opportunity, throw out foods they do not like (cf., Rose, 1989; Baker-Fulco, Chapter 8 in this volume). Also, there are time constraints that may prevent heating and preparing the rations. There appears to be a fatalistic attitude on the part of commanders and troops about the weight loss, which additionally may contribute to underconsumption and often deliberate dieting (see Baker-Fulco, Chapter 8 in this volume).

*In summary,* energy intake of men and women decreases in the field compared to the garrison during training. In the MRE field studies using doubly labeled water, there appears to be an energy deficit of 500 to 2,000 kcal/d and resultant weight loss for the study participants. When men and women trainees were given the opportunity to augment their rations with snack food or when regularly scheduled hot meals were provided, body weight was maintained.

### Effects of Ration Modifications in Energy Intake, Weight Change, and Food Acceptance

Five studies that compared the original MRE with improved versions containing 15 to 51 percent substitutions of new food items (see Hirsch, Chapter 9 in this volume) increased the ratings of soldier acceptability. However, increases in acceptability were only accompanied by increases in energy intake in four of the five studies. In other studies with improved T Rations, although there was an increase in acceptance, there was no increase in energy intake. These results must be viewed with caution as the limited increase in consumption might be due to the introduction of dietary variety (Rolls and Hetherington, 1989) or to the novelty effect of these new, highly palatable foods. These data thus raise an additional research question of whether heightened acceptance ratings and increased consumption might decline with repeated exposure to these new food items. Edward Hirsch (see Chapter 9 in this volume) has suggested that monotony is likely to set in; however, studies have not been conducted to address this issue.

In addition, food acceptance as measured by hedonic ratings represents only one aspect of a complex issue. Certain foods such as bread, high starch-containing vegetables, and milk, which typically receive only average hedonic ratings, will continue to be consumed in quantity when other more highly rated foods will be rejected as no longer palatable (see further discussion later in this chapter and in Chapters 11 and 13). A broader range of foods and menus with increased variety may need to be considered. There are 18 MREs now proposed, but the effect of this variety of menus on intake needs to be tested

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over a period of time. In addition, carefully designed menu rotation studies that incorporate current understanding of the impact of variety, sensory specific satiety, temporal habituation patterns, energy density, the fat and fiber content of foods, and palatability on intake and body weight would provide directly relevant information (cf., Jordan et al., 1981; Kissileff, 1984; Levine and Billington, 1994; Porikos et al., 1977, 1982; Prewitt et al., 1991; Rolls, 1986; Rolls and Hetherington, 1989; Rolls et al., 1981, 1992).

*In summary*, the problem of underconsumption from the perspective of those scientists involved with the food development and testing aspect of rations is that, despite significant efforts to test operational rations and measure their acceptability in the field over the last 10 years, there continues to be generalized weight loss when compared to garrison feeding studies even with the same MRE rations (Hirsch and Kramer, 1993; see Table 1-2). Thus, any review of the problem must include situational factors, such as environment, social settings, logistics, and temporal considerations, as well as perceptions or image of ration acceptability, and the possible interactions of all of these on consumption behavior.

### When Does Soldier Physical Performance Decline as a Result of Lowered Consumption?

True underconsumption of food, in the face of continuing or increased expenditures of body energy stores, leads to weight loss. A loss of body weight, over time, thus appears to be the easiest guide for quantifying dietary underconsumption. However, for an accurate evaluation of weight loss data, it is important to know the changes in body composition that account for the lost weight.

As discussed in previous CMNR reports (IOM, 1992a, 1993), different combinations in the complex relationships between dietary intake and energy expenditure can result in widely different forms of weight loss. As examples:

- Initially, simple starvation produces primarily losses of fluids, electrolytes, and small amounts of lean body mass and body fat, but then the body begins to derive virtually all of its energy needs from its fat stores, while using every possible metabolic method to conserve body nitrogen.
- Weight losses due to acute disease or trauma are associated initially with predominant losses of body muscle mass because of the acute phase reaction. This loss of muscle mass may be accompanied by losses in water, electrolytes, and fat.
- Weight losses associated with extreme energy expenditures during periods of food restriction (such as in U.S. Army Ranger training [Moore et al., 1992; Shippee et al., 1994]) are associated with losses of body fat, as well as with losses of body water and muscle mass.

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- Abrupt weight losses (within 2$1$2$38 hours) associated with high energy expenditures in hot, humid environments or protective clothing are due mainly to acute losses of body fluid and electrolytes.

In assessing the degree of weight loss needed to induce measurable decrements in physical performance, Karl E. Friedl (see Chapter 14 in this volume; see also Table 1-2) reviewed data from a number of historical situations and studies, as well as data recently generated in separate studies of Scandinavian and U.S. Army Ranger trainees. There were some similar, overall conclusions that could be drawn from these diverse studies and weight loss situations: decrements in physical performance were not evident with minor degrees of weight loss or losses primarily of body fat.

In studies conducted at the U.S. Army Ranger Training School (see Chapter 14 in this volume), decrements in physical performance occurred when weight losses of 10 to 15 percent were recorded over the 6 to 8 weeks of this intensive training program. Data from these studies cannot be directly applied to other military situations because Rangers in training in the Ranger School are highly motivated, thus these results may not be indicative of what can be expected from regular military units. The rate of weight loss in this situation must be taken into consideration. Weight losses of as little as 3 to 5 percent in 24 to 48 hours or less are primarily due to dehydration and will result in reductions in performance (see for example Altman and Fisher, 1986). Weight losses of 6 to 10 percent in a similar time period are potentially debilitating and may adversely affect the health of individuals. Therefore, when evaluating the effects of underconsumption of operational rations and resulting weight loss, it is necessary to eliminate dehydration as a factor and be concerned with well-hydrated individuals in assessing the effect of weight loss on performance.

The rate of weight loss is also an important consideration in healthy and adequately hydrated individuals and is primarily related to the energy deficit. An approximate calculation is that a deficit of 3,500 calories equates to 1 lb of weight loss in overweight individuals. Therefore, extreme rates of weight loss in the presence of adequate hydration are indicative of severe underconsumption. A soldier of 160 lb body weight losing 10 percent of body weight or 16 lb in 2 weeks (14 days) would be experiencing a calorie deficit of approximately 16 x 3,500 divided by 14, or approximately 4,000 kcal/d. A similar loss in 4 weeks (28 days) represents an approximate daily deficit of 2,000 kcal/d; 8 weeks (56 days), 1,000 kcal/d deficit; and over 16 weeks (112 days), a 500 kcal/d deficit. Physically fit soldiers with less body fat than the usual, somewhat overweight individual would experience less fat loss and more reduction in lean body mass as weight loss progresses (see discussion in Altman and Fisher, 1988; Vanderveen et al., 1977). Therefore, the fit soldier is likely to have a reduction in performance capability related to the reduction in lean body mass similar to the studies with lean Gambian laborers, where

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changes in body weight were mirrored by changes in fat-free mass, and fat-free mass was significantly correlated with physical work performance (Diaz et al., 1991). Workers in less developed countries where energy deficits are common during certain seasons voluntarily reduce their physical activity to compensate for the reduced energy intake and thus help retain lean body mass (Scrimshaw and Young, 1989).

There is the suggestion from the data on Ranger Training School (Moore et al., 1992; Shippee et al., 1994; see Chapter 14 in this volume) that body weight loss of less than 10 percent in hydrated individuals may not significantly reduce physical performance. However, concern arises with continued energy deficits that may occur if troops are redeployed after losing 5 to 10 percent of their body weight and before having an opportunity to regain this lost weight. If inadequate energy intake continues and further weight loss occurs, performance deficits can be expected. In addition, voluntary physical activity will likely be reduced, and situations that demand high energy output may result in reduced ability to perform (Scrimshaw and Young, 1989).

A number of studies have shown that the work productivity of semi-starved laborers could be increased markedly by supplementing their energy intake (Diaz et al., 1991; Viteri, 1971; Viteri and Torun, 1975; see also reviews by Conzolazio, 1983; Spurr, 1986, 1990). Weight losses in some of the historical studies were also complicated, undoubtedly, by deficiencies of certain nutrients, such as individual vitamins and minerals. Iron deficiency anemia, for example, induces decrements in physical performance (Edgerton et al., 1979; Finch and Huebers, 1982; Gardner et al., 1977) that can be reversed by iron supplementation (Edgerton et al., 1979).

Multiple variables are known to complicate the evaluation of physical performance during periods of weight loss. Measured decrements in physical performance vary with the test procedure being used. Decrements in U.S. Ranger performance were best demonstrated by the incremental dynamic lift, a maximal lift capacity test (Moore et al., 1992). Load-lifting capability fell progressively by an average of 30 to 40 lb as Ranger training progressed to the third and fourth periods. The magnitude of performance decline correlated well with the percentage of weight lost by individual soldiers. In this study, a higher correlation was evident when decrements in lift capability were compared to losses in fat-free mass. In contrast, handgrip strength failed to show measurable decrements in the Rangers, even in the face of high percentages of body weight loss. Recently developed tests of jumping ability tend to yield performance data comparable to those generated by load-lifting tests (see Friedl, Chapter 14 in this volume).

Physical performance tested during prolonged, continuous efforts, such as marching, jogging, or cross-country skiing, can give different results from studies using acute tests of strength. Some of these differences may be due to the type of muscle fibers being affected by the weight loss, that is, fast-twitch versus slow-twitch fibers. And some differences may be dependent on the

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minute-to-minute availability of body glycogen and intramuscular triglyceride stores and glucose precursors.

Overall physical performance can also be estimated by a subject's oxygen uptake ($\dot{V}_{o2\ max}$), with declines being recorded as a percentage of maximal uptake. Declines in $\dot{V}_{o2\ max}$) may indicate lowered performance. Heart rates can give roughly comparable data, but these types of measurement are most valuable when performance during short bursts of activity is being assessed (cf., McArdle et al., 1991).

In most studies of weight loss caused by imposed food restriction, the subjects were constantly hungry, and they ate avidly whenever food was offered (cf., Moore et al., 1992; Shippee et al., 1994). Conversely, weight loss during periods of illness, trauma, or emotional disturbances is typically accompanied by voluntary underconsumption and a failure to consume food that is offered or readily available. The problem of lowered consumption by soldiers in field situations would seem to fall into this latter category. Based on the discomforts associated with the field situation—the anxiety, fatigue, aches and pains, and assorted other problems—decline of appetite is likely to be a prominent factor in explaining underconsumption of military operational rations. Field training or combat anorexia thus may be a result of a generalized stress response. Ibuprofen has been used experimentally to reduce cytokine-mediated effects of stress, such as loss of appetite (Beisel, 1991). A study of the impact of ibuprofen on appetite may determine if a cytokine-mediated underconsumption situation would disappear with ingestion of an agent that blocks cytokine formation.

*In summary*, historical evidence combined with recent detailed studies of weight loss during military special forces training suggest that essential physical performance is maintained in most individuals until hydrated weight loss approaches 10 percent of initial weight, provided the rations available are of adequate nutritional composition. Research has demonstrated a correction of physical performance deficits when nutritional deficits are adjusted for a sufficient time to recover lean tissue losses.

Many variables must be considered when assessing this relationship between physical performance and weight loss. These include the nature and duration of the physical performance being studied, the tests used to assess performance, and the body composition at the time of testing (in terms of losses in body fat, body fat-free mass, and key body nutrients, such as vitamins and minerals, body fluids and electrolytes, and the availability of body glycogen and intramuscular triglyceride stores and carbohydrate precursors).

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## Impact of Suboptimal Consumption of Military Operational Rations on Cognitive Performance

As reviewed by LTC Mary Z. Mays (see Chapter 15 in this volume), the effects of suboptimal ration consumption on cognitive performance paralleled the effects on physical performance, but there were many fewer studies. If weight loss can be equated with underconsumption, decrements in cognitive performance resembled those in physical performance in that no effects of minor degrees of weight loss were detected in tests of cognitive performance. Deficiencies in performance in these studies only began to appear when weight losses in well-hydrated soldiers approached or exceeded 10 percent of body weight (see summary in Table 1-2). An important consideration is hydration status. Studies with Air Force personnel have clearly demonstrated significant declines in cognitive performance with 5 to 10 percent losses in body weight over 24 hours or less because of dehydration (Altman and Fisher, 1986).

LTC Mays provides a number of pertinent answers to the related questions "Why do soldiers consume less than the full ration?" and "What factors influence this lowered consumption?" LTC Mays points out that the conditions which give rise to lowered operational ration consumption are really quite harsh and include such problems as severe climatic and environmental conditions, extreme fatigue, dangerous training scenarios, and tremendous energy expenditures. All of these factors combine with the unique nature of the rations themselves and the unattractive conditions under which the rations must sometimes be eaten.

In interpreting field data, it is impossible to differentiate among the effects of lowered consumption on cognitive performance, the effects of the field setting itself on cognitive function, and the adverse physical and emotional factors just mentioned. These factors certainly affect the eating behavior of soldiers in such settings.

The concern of military personnel to meet body weight standards also must be considered. Many soldiers think of peacetime field training periods as an excellent opportunity to reduce dietary intake and to lose weight to meet these standards. When asked prior to field training exercises about their desire to lose or gain weight, 12 to 86 percent of soldiers intended to try to lose weight during the upcoming exercises (Edwards et al., 1989; USACDEC/ USARIEM, 1986; see Baker-Fulco, Chapter 8 in this volume). This attitude could contribute to voluntary food restriction during training.

Similar to the tests used to assess physical performance, tests of cognitive performance are subject to many variables present in the field setting. Studies of mood are often difficult to interpret, as are soldier self-reports about their performance decrements. At present, the Military Nutrition Division at USARIEM and the food products group at NRDEC do not use a standardized test battery for cognitive testing (see Mays, Chapter 15 in this volume).

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TABLE 1-2 Research Depicting Body Weight Loss and Changes in Performance in Military Personnel

| Study | Duration (days) | Relative Δ (%) Body Weight | Performance Tests | Test Results |
|---|---|---|---|---|
| *Physical Performance* | | | | |
| Consolazio et al., 1979 | 10 | NC* | $\dot{V}_{o2}$max† | -2.0% |
| Teves et al., 1986 | 44 | NC | Maximal lift‡ | NC |
| Askew et al., 1987 (MRE) | 30 | -1.6 | Grip strength, ILE§, $\dot{V}_{o2}$max | NC, NC,-10.2% |
| Askew et al., 1986 | 12 | -2.8 | $\dot{V}_{o2}$max, 2-h run performance | 5.7%, NC |
| Roberts et al., 1987 (RCW) ** | 10 | 3.0 | ILE | NC |
| Consolazio et al., 1979 | 10 | -3.6 | $\dot{V}_{o2}$max | 11.0% |
| Consolazio et al., 1979 | 10 | -3.7 | $\dot{V}_{o2}$max | -7.4% |
| Roberts et al., 1987 (MRE) ** | 10 | -4.0 | ILE | NC |
| Askew et al., 1987 (RLW-30) | 30 | -5.0 | Grip strength, ILE, $\dot{V}_{o2}$max | NC, -8%, -14.8% |
| Consolazio et al., 1979 | 10 | -5.0 | $\dot{V}_{o2}$max | +5% |
| Taylor et al., 1957 | 12 | -7.4 | $\dot{V}_{o2}$max | -4.0% |
| Johnson et al., 1976 | 60 | -9.4 | $\dot{V}_{o2}$max | -14.1% |
| Taylor et al., 1957 | 24 | -10.2 | $\dot{V}_{o2}$max | -10.1% |
| Frykman et al., 1993 | 60 | -13.0 | Maximal lift, jump power | -21% |
| Johnson et al., 1994 | 60 | -16.0 | Maximal lift, grip strength | -24%, NC |

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| | | | | |
|---|---|---|---|---|
| Cognitive Performance | | | | |
| Askew et al., 1987 | 10, 30 | -1.6, -5.0 | Vigilance, encoding | NC |
| Askew et al., 1986 | 12 | -2.8 | Various | NC |
| Roberts et al., 1987 | 10 | -3, -4 | Various | NC |
| Crowdy et al., 1982 | 12 | -3, -6 | Marksmanship, vigilance, arithmetic, coding | NC |
| Shippee et al., 1994 (Benning Phase) | 13 | -6.0 | Decoding, memory, reasoning, pattern recognition | NC |
| Hirsch et al., 1984 | 34 | <-5% or >-7%†† | Battery of cognitive and psychomotor tests | NC |
| Shippee et al., 1994 | 60 | -12.6 | Decoding, memory, reasoning, pattern recognition | -10 to -34% |
| Keys et al., 1950 | 60 | -16.0 | Memory, reasoning, spatial perception | NC |

* NC, no change.

† $\dot{V}_{o2\ max}$, changes in Treadmill Maximal Oxygen Intakes; measures aerobic capacity.

‡ Maximal lift, measures strength; can be confounded by skill level.

§ ILE, isokinetic leg extension; measures strength.

** High urine specific gravity results suggest that a significant amount of the weight losses in this study may have been due to dehydration.

†† Number of subjects in each group = 8.

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Standardized cognitive test batteries are used in other military research and would be useful in studies of ration intake.

It is also difficult to gather reliable baseline data on soldier food intake patterns. For example, the sudden appearance of dietitians taking notes, asking questions, and documenting soldier eating patterns can hardly be expected to produce normative data. It is also difficult to establish realistic control groups. The motivation of the soldiers being tested can vary greatly, with problems of both over- and undermotivation and a tendency to approach testing as game playing. Analysis and reporting of data can also introduce problems. Group means provide little information about extremes that might be present among group members.

Due to deficiencies in available data, it might be useful to evaluate other models of underconsumption, such as anorexia nervosa, illness, malignancy, trauma, aging, weight control used by athletes, and studies of fasting and food deprivation. Animal models may not be appropriate, because food deprivation in animals may cause increased alertness and activity. In addition, the effects of mood, motivation, and relevant contextual and cognitive factors cannot be tested with animal models.

*In summary*, the small amount of data available suggests that lowered energy intake may degrade cognitive performance when it leads to weight loss greater than 10 percent of body weight over 4 or more weeks. Research that addresses the cognitive aspects of underconsumption should include monitoring of body weight and cognitive performance at all stages of each study. Care should be taken to include longitudinal studies with good baseline measures of body weight, some indicators of body composition for each participant, and initial cognitive performance scores. Future experimental designs should eliminate (or minimize) serious problems found in previous research, such as the establishment of suitable control groups, normative baseline control data, cognitive test standardization and reliability, test condition standardization, subject motivation, and measure performance over a range of body weight losses.

## Implications of Underconsumption of Macronutrients

Related to the underconsumption of military operational rations is the optimum composition of rations in terms of the macronutrients carbohydrate, fat, and protein. These issues were considered by Stephen D. Phinney in Chapter 16 and Carol J. Baker-Fulco in Chapter 8. As early as the first half of this century, there was a strong difference of opinion between nutritionists who advocated a high-carbohydrate, low-fat diet for optimum physical performance and polar explorers who, for reasons of practicality, advocated compact high-fat rations, such as pemmican, which was developed during World War II. An experiment was conducted with Canadian military personnel who were

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abruptly switched from their usual ration to a dried meat and fat ration (pemmican) as their sole source of energy. Arctic maneuvers requiring high energy were carried out, and the soldiers became debilitated in 3 days (Kark et al., 1946). In contrast, Stefanson, a former arctic explorer, lived successfully and actively for a year at the Russell-Sage Research Institute, Bellevue Hospital in New York, on a diet exclusively composed of meat, fat, internal organs, and bone marrow (McClellan and Dubois, 1930). The key to the utilization of high-fat diets, as pointed out by Phinney (see discussion in Chapter 16 in this volume), is the critical nature of a period of adaptation, appropriate vitamin and mineral supplementation, plus energy expenditures at a high enough level to utilize the fat consumed.

One of the issues of concern with diets of this nature that are low in or devoid of carbohydrates is the development of ketosis. Phinney and colleagues fed five highly trained cyclists a ketogenic diet composed of 15 percent protein, 0 percent carbohydrate, and 85 percent fat, which supplied 1.75 g of protein per kg of body weight per day. The diet was supplemented with vitamins and minerals including 3 g of sodium. The cyclists were studied at rest and with exercise. It took 3 weeks to adapt to the diet, and by the fourth week both endurance time and peak aerobic power had returned to baseline values (Phinney et al., 1983). While the data were collectively presented as a mean for the five cyclists (individual performance measures varied), this study emphasized the need for a period of adaptation and adequate amounts of sodium, calcium, and magnesium. The study described by Phinney suggests that, under the conditions of his experiment, there is no metabolic requirement for dietary carbohydrate because sufficient carbohydrate can be synthesized from glycerol and amino acids to prevent ketosis.

However, the importance of dietary carbohydrate to maintain a high level of physical performance, including endurance, is generally accepted (Evans and Hughes, 1985; Hargreaves, 1991). The carbohydrate needs of elite athletes were recently reviewed by Williams (1993). In this review actual measured carbohydrate intake of a variety of male athletes ranged from 373 to 596 g/d with energy intakes of 3,034 to 5,222 kcal/d. Corresponding data for female athletes were 290 to 428 g of carbohydrates per day with energy intakes of 1,931 to 3,573 kcal/d. In a comparison of food intake across military field feeding trials, Carol J. Baker-Fulco (see Chapter 8 in this volume) found that carbohydrate intake was typically less than 400 g/d. After reviewing many studies, Williams concluded "the question of how much carbohydrate should be consumed cannot be answered with any great precision" (Williams, 1993, p.56). This statement is appropriate not only for athletes but also for troops in the field.

In an earlier report, the CMNR reviewed a proposed high-density, high-fat special operational ration designed to minimize weight and space for military units on extended patrol when they were carrying all of their food and equipment. Because of the concern that troops would not likely be adapted to

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a high-fat ration, it was recommended that this specific ration also should provide a minimum of 400 g of carbohydrate per day to prevent a serious problem of ketosis if troops were fed this ration with no period of adaptation. An adequate level of carbohydrate would aid in maintaining and restoring muscle glycogen, and help sustain performance and prevent chronic fatigue in physically active troops. In addition, this level of carbohydrate would prevent the development of ketosis and the resultant adverse performance that may occur in troops not adapted to the high-fat diet (IOM, 1992b).

In his review, Stephen D. Phinney (see Chapter 16 in this volume) discusses energy deficits resulting from reduced food intake, illness, injury, or increased physical activity. Depending on circumstances and hydration state, early weight loss will include loss of water, loss of body fat, and loss of lean body mass unless protein intake is maintained at a high level. Energy deficits induced by increased physical activity are not likely to result in loss of lean body mass if protein intake is maintained at least at 1 g per kg of body weight per day, according to Phinney. Energy needs can be calculated as described by the Recommended Dietary Allowances (RDA) Committee (NRC, 1989) or estimated most accurately using the doubly labeled water technique (Jones et al., 1993). Pavlou (1993) recently described equations that can be used to predict the energy needs of athletes. The protein needed for high-level physical performance was defined by Evans (1993) as 1.2 g per kg of body weight per day and by Lemon (1991) as 1.2 to 1.7 g per kg of body weight per day depending on the event (12–15 percent of energy intake). At the levels of energy intake that occur with increased physical activity, and with the increased efficiency of protein utilization that occurs with higher energy intake, protein at 12 to 15 percent of energy intake (assuming protein quality typical of a typical American diet) should easily provide enough dietary protein. In field trials with operational rations, mean protein intakes typically are 100 g for men and 80 g for women (see Baker-Fulco, Chapter 8 in this volume).

Whether the results of these studies on athletes can be applied to troops in the field can be questioned. The athletic events range from running and swimming to a variety of team sports. The term *elite athlete* typically denotes a high level of physical performance, not necessarily a specific energy expenditure. Troops in the field often expend 3,000 to 4,500 kcal/d, and in many respects they resemble elite athletes in this context. The CMNR believes that the data obtained with athletes are relevant to troops in the field under these conditions.

*In summary*, these examples suggest that physical performance is well maintained during undernutrition if adequate protein, vitamins, and minerals are supplied and loss of lean body mass is minimized. Phinney recommends that protein should be supplied at 1 to 1.5 g per kg of body weight per day, preferably at the higher level. Supplying at least 100 g of carbohydrate per day in the standard operational ration that contains a maximum of 160 g of fat is desirable to prevent ketosis. Research with military personnel under various

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field training conditions indicates that protein intake is typically adequate, while energy and carbohydrate intakes are lower than desired.

## ATTRIBUTES OF EATING THAT AFFECT CONSUMPTION

### The Physical Eating Situation

For the soldier, the military eating situation can vary from highly monotonous and predictable to continually changeable and highly unstable. In garrison, dining hall managers strive to provide a variety of foods in a comfortable setting, and current approaches include both varied menus with many alternative item choices and nutrition education materials to enhance healthy eating habits. Nonetheless, the image of the military dining situation remains negative. In a study that compared the ratings by military personnel of Navy dining halls with commercial foodservice establishments for 16 different aspects of foodservice, the Navy foodservice scored significantly lower on all aspects of foodservice with the exception of air quality (Navy dining halls are smoke-free). Factors as disparate as temperature of the dining areas, lighting, taste of food, number of items per meal, and portion size all received significantly lowered ratings (Salter et al., 1990; see Cardello, Chapter 10 in this volume).

There are a number of factors that often lead to soldiers skipping meals or reducing their intakes. In the field, soldiers typically do not have the opportunity to eat under cover, and it is often difficult to prepare or eat a meal. In addition, the physical demands of training or field exercises coupled with the additional stress of high performance expectations may result in soldiers choosing to rest or complete a mission instead of eating. The process of deployment or transportation to the field can involve long periods of time and leaves little opportunity for soldiers to eat or drink. In one study, the average hydration and body weight changes during a 24-h deployment were approximately half of the changes observed in the total 11-d training period (Popper et. al., 1987; see Kramer, Chapter 17 in this volume). Hypohydration has been shown to decrease food intake, and therefore a suboptimal hydration status may lead to reduced food intake (see Engell, Chapter 12 in this volume). Ration consumption in the field may also be affected by changes in circadian rhythms, soldiers' attitudes toward weight loss and food intake while in the field, meal timing, meal frequency, meal duration, meal regularity and predictability, ease of access to the food, food appropriateness, and lack or reduction in food sensory cues due to packaging. All of these factors have been shown to affect food intake adversely in experimental settings (see Kramer, Chapter 17 in this volume).

As described above, eating is associated with many nonfood factors that constitute the entire eating event. The setting in a dining room or cafeteria,

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silverware, familiar dishes, and a table and chair at a comfortable height for dining are examples of specific nonfood cues that are linked to beginning and ending a meal (Weingarten, 1984). In the field setting, soldiers have few of these cues, and often wind, sand, dirt, or temperature factors contribute to making the eating of a meal not only unpleasant but difficult. Results from conditioning studies with animals and humans indicate that familiar nonfood cues tend to stimulate eating and metabolic responses (Cornell et al., 1989; Woods et al., 1977). These studies show that familiar nonfood cues stimulate additional eating or a desire to eat even after an individual is satiated or there is no food available. As discussed by F. Matthew Kramer (see Chapter 17 in this volume), familiar nonfood cues in the eating situation play a role in anticipatory learning (Moore-Ede, 1986; Woods, 1991), and a lack of cues may reduce the desire to eat. Combat, or the prospect of imminent combat, also will tend to increase anxiety and decrease appetite. Adequate time and appropriate times to eat also become important under these conditions.

*In summary*, the field setting, and often deployment to the field setting, include many factors that reduce soldiers' desire to eat or to reduce their food intake. Whenever possible, deployment to field training exercises should provide ample opportunities for soldiers to eat and drink. The resulting exercises should take into account changes in circadian rhythms, meal timing, and the appropriateness of meal items to encourage food intake. Providing meals in a more typical meal setting at tables should be encouraged. The literature in environmental psychology and acquisition of learned behaviors provides a strong theoretical base for understanding the impact of the eating situation on food intake, but more research is needed specifically to address issues of increasing rather than decreasing food intake in general, and in military field settings in particular.

## Social Facilitation of Food Intake

The social environment plays a prominent role in determining human behavior. Social facilitation of behavior, or an increase in the frequency or intensity of an individual's behavior in the presence of others engaged in a similar behavior, is a frequently observed phenomenon (Zajonc, 1965). In Chapter 20 of this volume, John M. de Castro reviews his own and others' research on social facilitation and human food intake. This research demonstrates that, under laboratory conditions, individuals consume more food in the presence of others than when eating alone (e.g., Berry et al., 1985; Conger et al., 1980; Goldman et al., 1991). However, these studies may not be very relevant to the field situation because the effects of social facilitation were only examined using single meals consumed in an artificial laboratory environment.

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To determine if social variables also could influence the food intake of free-living individuals, de Castro and colleagues used a diet diary technique in which subjects recorded meal time and location, food and drink consumed during the meal, affective state, and the number and identity of other people eating with them (de Castro, 1990, 1994; de Castro and Brewer, 1992; de Castro and de Castro, 1989). Results of these studies revealed that meals eaten with other people were substantially larger than meals eaten alone. The greatest increase in intake was observed when individuals went from eating alone to eating with one other person. However, it should be noted, the more people who were present, the larger the meal consumed (de Castro and Brewer, 1992). The direct relationship between the number of people present and meal size was observed for meals consumed as breakfast, lunch, or dinner; in restaurants or at home; and on weekdays or weekends. Although social facilitation of feeding was observed regardless of the identity of the eating companion, it was more pronounced when meals were consumed with family or friends than when meals were eaten in the presence of other individuals (de Castro, 1994). On the basis of this research, de Castro hypothesizes that the presence of other individuals, particularly family and friends, may augment food intake by (1) increasing verbal interactions that would result in longer meal durations and thus increases in the amount of food eaten, and (2) relaxing the individual and thereby decreasing inhibition of food intake.

*In summary*, research on social facilitation of feeding suggests strategies that could be employed to increase consumption of military operational rations. For example, if strategically feasible, allowing soldiers to eat in pairs or larger groups could promote intake of rations. Intake might be particularly enhanced if groups were composed of individuals who knew each other well, and if the situations were conducive to verbal interactions that could increase meal duration. If the preceding conditions cannot be met in the field, de Castro suggests that modeling behavior where one soldier is instructed to eat large amounts in the presence of soldiers who consume smaller amounts or where direct orders are given from commanding officers might increase intake of rations. Clearly, however, in a combat situation, the ability to increase food consumption through improvement of physical and/or social factors is limited.

### Commanders' Perceptions and Attitudes about their Responsibilities for Feeding Soldiers

As an extension of the modeling concept, it is apparent that the attitude of the leader in the field regarding ration acceptance will affect ration consumption. A survey by Celia F. Adolphi of former commanders attending the Army War College in 1991 provided initial information on commanders' understanding of the relationship of diet to soldier performance (see Chapter 5 in this volume). Of the 113 responding to the survey, 50 percent of whom

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had commanded combat units, only 7 percent could answer correctly 10 nutrition knowledge questions. These results were remarkable in comparison with a group of basic trainees, of whom 64 percent could correctly answer the same nutrition questions. In addition, only about half of the commanders thought there was a positive relationship between diet and the combat performance of their troops. When asked to rank order their rationale for determining what type of rations to use during field operations, the top three reasons given were training scenario, time to prepare rations, and soldier preference. Slightly over half were involved in decision making about rations. Respondents indicated that information on nutrition came from drill sergeants, master fitness trainers, physician assistants, or popular magazines. Commanders commented that soldiers purposely planned to lose weight during field training. Provision of nutrition education[2] to the various levels of supervision in the military could help improve commanders' appreciation of the diet/performance relationship.

A number of possible mechanisms were proposed by Adolphi as an outgrowth of the commanders' survey (see Chapter 5 in this volume). In addition to conducting an ongoing survey of commanders and soldiers returning from Somalia or other nonwar operations, she recommended the following:

- include hierarchical and progressively more complex health promotion (including nutrition) in U.S. Army Training and Doctrine precommand and command courses;
- train physician assistants to teach the fundamentals of diet and performance (since they are the only medical personnel who interface with soldiers);
- provide USARIEM Technical Note 93-3 (Thomas et al., 1993), *Nutrition for Health and Performance: Nutritional Guidance for Military Field Operations in Temperate and Extreme Environments*, to commanders; and
- periodically survey Army War College and Command and General Staff College classes to measure understanding of the importance of ration consumption to performance.

## Eating Situations, Food Appropriateness, and Consumption

A number of factors including appetite, hunger, liking, availability, and appropriateness of the food contribute to human food consumption. In Chapter 18

[2] The recently revised USARIEM Technical Note 93-3 (Thomas et al., 1993), *Nutrition for Health and Performance: Nutritional Guidance for Military Operations in Temperate and Extreme Environments*, provides information in an understandable format.

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in this volume, Howard G. Schutz evaluates the role of the appropriateness of a food item to the eating situation in governing food intake. Appropriateness of a particular food can vary according to meal occasions, attitudes about the food, and the physical and social environment. Consumer behavior studies and cognitive-context research indicate that individuals have definite ideas about the appropriateness of a food for given occasions (e.g., meals versus snacks; breakfast versus dinner; family meals versus special occasions), particular contexts (e.g., cold days versus warm days), and specific individuals (e.g., adults versus children, men versus women) (Belk, 1975; Hugstad et al., 1975; Miller and Ginter, 1979; Schutz, 1988). Results of this research indicate that measures of hedonic qualities of a food or food acceptance do not necessarily predict how appropriate the food will be rated for a given situation. For example, although three meat products may have similar acceptance ratings, the appropriateness ratings for the three may differ significantly as a function of the context in which the foods are assessed. On the basis of this research, Schutz proposes that foods are less likely to be consumed when they are served in an inappropriate use situation than in an appropriate use situation.

*In summary*, research suggests that, if possible, consideration should be given to the appropriateness of the items contained in the ration to situational variables including the time of day, temperature, and social environment. Providing appropriate foods might result in an increased intake of rations.

## ATTRIBUTES OF FOOD THAT AFFECT CONSUMPTION

### Food Stereotypes and Food Image

Military operational rations and garrison food have a negative image both with the American public and with the soldier. This image is perpetuated in the media through articles whenever soldiers are deployed and, more consistently, through well-known, long-standing comic strips such as "Beetle Bailey." In a recent questionnaire, active-duty soldiers rated the expected acceptability and expected quality of 12 different foods as served in 7 different types of commercial and military eating establishments (A. V. Cardello and R. Bell, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995; see Cardello, Chapter 10 in this volume). The 12 food items listed in the questionnaire were selected to represent both items where the quality would be expected to vary with the location of preparation (e.g., steak) and items for which the expected variability would be less (e.g., soda). For all food items, in terms of both expected acceptability and quality, food prepared and served at home received the highest rating while responses to military food clustered at the lowest ratings, along with hospital and airline foods, for all food items. Because the subjects in the first study were all familiar with military food, the same

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questionnaire was also administered to an age-matched group of students who had never eaten military food. The students' results were similar and therefore indicated that a negative image of military food is widespread in the general population and is not necessarily related to exposure to the food itself. These findings have been supported by a study of food acceptability in Navy dining facilities (Salter et al., 1990; see Cardello, Chapter 10 in this volume). Hedonic properties of military foods—flavor, variety, and appearance—are the primary factors that contribute to this poor image of military foods (A. V. Cardello and R. Bell, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995). In addition, civilians indicated that movies and television shows were the source of their poor opinion of military foods, whereas soldiers indicated that their opinions were based on early experience with military foods during training.

Product acceptance is not only a result of the intrinsic quality of the food. It can also be related to appetite and to the expectations a consumer has for a food item and the degree to which the food matches these expectations (Cardello, 1994; Cardello and Sawyer, 1992; see Cardello, Chapter 10 in this volume). The bulk of consumer psychology research supports an *assimilation model* (Sherif and Hovland, 1961) for predicting the relationship between food quality and acceptability. As discussed by Armand V. Cardello in Chapter 10 in this volume, for military operational rations this model predicts that if expectations for rations are low, then acceptance of the rations will be low. Given the poor image of military operational rations among both soldiers and civilians, continued poor acceptance of even the newly developed rations would be expected. The assimilation model also predicts that if expectations are changed, then ration acceptance should improve. Informational variables such as packaging can play an important role in changing consumer expectations and, hence, acceptance. Acceptance and food preferences have been shown to contribute significantly to variability in food consumption (cf., Smutz et al., 1974; Wyant et al., 1979). In recent studies, soldiers rated food products in military packaging lower and consumed them less than the same products in commercial or "commercial-like" packaging (Kalik, 1992; Kramer et al., 1989). NRDEC also has developed several film clips to attempt to positively change military and civilian expectations, hence acceptance, of operational rations. The two films presented at the workshop effectively used humor to present the message that the MREs were new and improved. The scientifically measured impact of these and other similar media approaches to changing the poor image of rations is a promising area of research.

*In summary*, military food products have a poor image both among soldiers and civilians. These stereotypical negative expectations appear to be based not only on experience with the food items but also on exposure to mass media. Current models of consumer psychology and recent research with military food packaging indicate that acceptance and intake of military rations may be enhanced by adopting a more commercial-like package. Additional

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research is needed on the most effective attributes of this packaging and the effects of packaging changes on intake of individual food items, as well as on an entire meal. Based on the assimilation model, improving the image of military food through media and packaging could make a significant change in ration intake. Recent media approaches that incorporate humor into the marketing of new rations have the potential to change both civilian and military images of rations.

## Food Quality, Quantity, and Variety

In Chapter 11 in this volume, Barbara J. Rolls discusses how food intake and satiety are influenced by the composition and presentation of foods. The basic question is whether available knowledge regarding food satiety and diet variety could be applied to diet formulation to increase energy intake among soldiers. She noted that palatability is a key determinant of energy intake among humans, although other characteristics may also be important.

Foods that are highly palatable will initially be consumed in greater quantity than less palatable foods. But palatability falls as a given food (and related foods, such as sweets) is eaten (de Graaf et al., 1993). Palatability for unrelated foods is unaffected, however, a fact that promotes variety in eating (Rolls et al., 1984). There are several bases for such changes in palatability, but one can use this knowledge to maximize palatability throughout a meal so as to increase intake. Over the longer term, however, monotony becomes an important factor in food intake. For example, repeated presentation of canned meats makes them unpalatable. The development of such aversions is not a property of all foods. The palatability of foods such as fruit, sweets, cereal, dairy products, bread, or coffee does not decrease as a consequence of repeated presentations (Schutz and Pilgrim, 1958; Siegal and Pilgrim, 1958). Such knowledge should allow the construction of diets that frequently include items showing no aversion over time, while varying those that do.

Among other dietary characteristics important to intake is the energy density of foods (Duncan et al., 1983). Low-energy dense foods can be satiating, despite their low-energy content (e.g., soups) (Kissileff et al., 1984; Rolls et al., 1990). High-density foods appear to be less satiating. These foods often contain higher amounts of fat, and current data suggest that satiety signals are not strong for dietary fat. Fat-containing foods thus tend to be overeaten (except possibly in young, normal-weight men) (Rolls and Shide, 1992; Rolls et al., 1992).

Another factor important to food intake is the fiber content of foods. Diets high in fiber reduce food intake, although the basis for this effect is not well understood (Levine and Billington, 1994). Food intake is also affected by portion size, with greater intake occurring when portion size is larger (Booth et al., 1981; Edelman et al., 1986; Shaw, 1973). Greater energy intake can also

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be promoted by the supply of energy-containing beverages; liquids as vehicles for energy tend to be less satiating than solids (Tournier and Louis-Sylvestre, 1991). Finally, the perceptions about foods may influence their intake, but there is too small a knowledge base to allow definitive statements on this relationship.

*In summary*, the key concepts for maximizing energy intake based on food quality and variety are the following: (1) the initial palatability of foods should be high, with self-selection allowed whenever possible; (2) the diet should be as varied as possible; (3) portion size should be as large as practicable; (4) diets should not contain undue amounts of fiber; and (5) energy intake may be enhanced by providing energy-containing beverages.

## Food as a Product

Eileen G. Thompson's presentation (see Chapter 13 in this volume) offers interesting perspectives based on industrial food products research. First, she mentions the value of studying the subject in as unobtrusive a manner as possible to learn about eating habits in each environment. Second, she offers insight into factors that affect food palatability, choice, and acceptability and possibilities for increasing energy intake among soldiers.

Regarding the first issue, one must know the target population. Soldiers in garrison are different from soldiers in the field, as office workers are different from construction workers. Their natural eating habits need to be examined *in situ* in order to determine their food habits, likes, and dislikes. Such observation needs to be unobtrusive and can be accomplished via cameras and by methods long used by anthropologists. To determine the dietary preferences for the soldier in the field, whose diet is prescribed and proscribed, it may be revealing to identify and study a closely matched group in general society, for example, young male construction workers. The importance of this approach is underscored by the likelihood that in looking at a matched group, one accounts for lifestyle similarities in physiological state.

Thompson also offers insight into how to optimize available foods to reach the desired objective from the industry perspective. First, to increase product acceptability (and demand for it), a valid approach is to find a combination of products that optimizes *overall* product line use. Industry may test the preferences for different flavors of a given product, and rank them accordingly, but it does not then simply choose the highest ranked selections to produce and market. An analysis is conducted to determine the selection of flavors (or other characteristics) that would provide the greatest overall acceptance of the product. The final mix may be different from simply the most highly rated choices. Such an approach may be of use to the military in creating variety in rations to optimize acceptance. Second, she discusses a result that might be of

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relevance to soldiers in the field: snacking behavior, particularly the so-called "random nibbling" phenomenon. If snacks are available at hand during work periods, they tend to be consumed continually without thought. Such nibbling behavior can lead to significant energy intake each day (Jenkins et al., 1989). If the problem for soldiers in the field is that they do not consume enough energy, maybe an analog for random nibbling would be desirable. Third, Thompson notes that packaging may affect acceptability among soldiers, as it does among civilians, and should be examined. And finally, regarding sensory issues, seasonings are being used more and more in industry to enhance variety and acceptability of food products, with great success. This approach may be relevant for the military as well.

### Beverage-Food Interactions

Dianne Engell (see Chapter 12 in this volume) discusses the relationship of water intake to survival and performance. She focuses her discussion particularly on the factors that influence fluid intake and on how fluid intake affects energy intake.

She and her colleagues have examined the impact on MRE consumption and energy intake of the types of beverages supplied with these meals. As noted earlier, fluids can be a significant energy source. Engell states that energy intake from beverages in the early MREs was 8 to 10 percent of total calories (Engell et al., 1987; Hirsch et al., 1985; Popper et al., 1987); this percentage rose to 15 to 17 percent when flavored fruit drinks were provided (Lester et al., 1989; Popper et al., 1987), and reached 20 percent when flavored shakes were supplied in the MREs (Lester et al., 1993). The results indicate that as the number of energy-containing beverages in the MREs has increased, their consumption has led to increases in total energy intake.

Engell also discusses how fluid consumption affects energy intake from solid foods. Several studies show that when fluid intake is restricted, food intake and body weight fall (Adolph and Wills, 1947; Adolph et al., 1947; Bass et al., 1955; Engell, 1988). This effect is related to the state of hydration over time, rather than to peripheral thirst sensations or to the need to lubricate foods (Engell, 1993; Rolls et al., 1990). Such results indicate the importance to energy balance of ensuring adequate fluid intake to maintain normal hydration.

Finally, she discusses some of the factors that influence fluid intake. Her studies show, for example, that accessibility has a strong influence on intake, when studied in garrisoned troops (Engell and Hirsch, 1991). In the field, data are available showing that water is perceived as being less accessible, which suggests that intake may be less than desirable. Daily fluid intake is also influenced by the setting: the largest portion of daily fluid intake accompanies meals and is influenced by social circumstances. Finally, the intake of fluids

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is strongly influenced by their hedonic attributes, although this relationship has not been carefully examined in field studies.

*In summary*, the key points regarding fluid consumption and fluid related energy intake among troops in the field are: (1) improve hedonic qualities and variety of beverages supplied in the field to increase fluid intake, (2) optimize social settings in the field (e.g., mealtimes) to enhance fluid intake, (3) increase the convenience of obtaining water in the field, (4) encourage officers to promote increased fluid consumption among troops, and (5) conduct further research on the factors that influence fluid consumption and on the use of fluids to enhance energy intake.

### Biological Rhythms and Timing

In Chapter 19 of this volume, Franz Halberg and colleagues discuss the influence of alterations in the diurnal pattern of food intake on physiologic functions of the body. In particular, Halberg's work has shown that the ingestion of a single daily meal in the evening promoted better weight maintenance than one consumed in the morning. A careful examination of meal timing in relation to the daily performance cycle in military personnel in the field might thus reveal if meal timing might be useful in optimizing body weight and performance.

## NEW CHANGES IN MILITARY OPERATIONAL RATIONS AND FIELD FEEDING

### Ration Evolution

Development and testing of military operational rations has been an ongoing component of the military, and the use of nutritional standards for rations has been in place since World War II (for a review see Schnakenberg, Chapter 6 in this volume). All military rations are expected to meet the Military Recommended Dietary Allowances (MRDAs) (see AR 40-25, 1985) with the exception of restricted rations, which are currently the Ration, Lightweight; the Long Range Patrol Food Packet; and the Survival General Purpose, Food Packet. There are also separate specifications for these restricted rations, which are provided to sustain soldiers for no more than 10 days. Testing of military operational rations is prescribed in procedures and policies approved by the Office of the Surgeon General (OTSG) of the Army and is conducted jointly by USARIEM and the Sustainability Directorate at NRDEC.

The MRDAs (included in AR 40-25, 1985) define both the recommended allowances for evaluating what people should consume and nutritional standards for development and procurement of the ration. However, the criteria

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for testing rations are not specified, and USARIEM has had a major role in their development, as did the OTSG of the Army.

Prior rations have included the K Ration in World War II and the C Ration (Meal, Combat Individual) in tin cans during World War II and Korea (see Schnakenberg, Chapter 6 in this volume for a more detailed history). The MRE ration was developed to replace the C Ration in the 1970s and 1980s and can be used for up to 21 days (U.S. Department of the Army, 1995).

Many constraints exist in developing rations (see Darsch and Brandler, Chapter 7 in this volume). These constraints include acceptance, nutrition, wholesomeness, productivity, cost, sanitation, cultural appropriateness, variety, usage in a variety of environments, the need for withstanding air drops, shelf life equal to or greater than 3 years, minimal weight and size, and the capacity to self-heat and be assembled in modules tailored to the ration needed. In addition, the packaging must be protective in response to nuclear, biological, and chemical threats during war. Finally, there are performance enhancement characteristics that may affect the formulation of specific components (IOM, 1994).

The program of continuous field improvement is reviewed in depth for all classes of rations by Gerald A. Darsch and Philip Brandler in Chapter 7 and Edward Hirsch in Chapter 9 of this volume. A review of the ration types is included earlier in this chapter.

A new combination, the Unitized Group Ration (UGR), has been developed to simplify logistics of ordering and meal preparation in the field. The UGR uses components of the A Ration (without the perishables), the B Ration, the T Ration, and additional brand-name items combined in a unified system. Fifteen breakfast and 30 lunch/dinners are available. The UGR increases field feeding efficiency and reduces the number of items that a cook has to order to get the necessary items for a meal.

Based on direct feedback from Desert Shield/Storm, the OTSG of the Army, and the CMNR, an increasing emphasis is being placed on nutritional labeling and nutrition information on operational rations. Guidelines are now being developed to provide appropriate consumer-oriented information.

In the future, the goals are to develop self-heating rations with "fresh" quality yet shelf-stable and suitable for both individual and group feeding. Pending further approval, a self-heating group meal is in the planning stages; the meal module would include all accessories, be modularized similar to the UGR, but provide food for 18 soldiers. This concept has been called "Kitchens in a Carton."

*In summary*, military operational rations are under almost continual revision. Ration developers are concerned to provide the best possible product for their consumers and at the same time be cognizant of the factors related to packaging, shelf-life, transport, and distribution. New developments such as shelf-stable bread products and the flameless ration heater will significantly broaden the scope of food products available for individual rations.

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### The Current Situation with Army Field Feeding

Some of the major problems faced by the Army with feeding troops in the field include logistics, time, the quality of the food preparation and packaging, the lack of hot/cold alternatives with certain food items, and the lack of cooks in the forward areas. Added to these problems are the realities of combat itself. The MRE has some advantages in these circumstances, but when it does not include a flameless heater, lack of hot foods is still a significant deterrent to energy intake (for a discussion, see Motrynczuk, Chapter 4 in this volume).

The logistics of supply may thus play a role in underconsumption of rations. The military feeding system in the field in the recent past, based on Army field feeding policy, has relied primarily on MREs and T Rations unless field kitchens were accessible. The policy was that commanders should provide soldiers with two T Rations per day and one A or B meal every 3 days. The recent Desert Shield/Storm conflict demonstrated that forward units might well not be supplied with even T Rations for periods of up to 60 days. This situation, in many cases, was the commander's decision, as the commander's responsibility according to policy was to provide soldiers with three quality meals per day, Mission, Enemy, Terrain, Troops, and Time (METT-T) dependent. Thus, long-term consumption of the MREs and any supplemental packs was a frequent occurrence depending on the scenario and the distance from battalion support services. In this environment, depending on time to reach the forward lines, hot meals in the form of T Rations might take 6 to 10 hours, and availability of hot fluids was limited to what the soldier could heat on his own. Thus, the logistics of supply and the system for field food preparation becomes extremely important in long-term support.

In response to the problems encountered in Desert Shield/Storm, a new strategy for field feeding was developed that will provide soldiers with at least one cook-prepared meal (A or B Rations[3]) everyday and has now been approved by the Army Chief of Staff (Decision to Increase the Number of Military Cook Personnel, unpublished Army doctrine, June 1992). The major changes will be to have an enhanced company-level field feeding truck with two cooks, which will provide hot meals and perishable foods on a daily basis and be able to follow the unit on maneuvers. These field kitchens will be supervised by a foodservice technician at the brigade level who will develop the feeding plan for brigade-size exercises and ensure that the ration fits the unit scenario. This procedure will allow planned variety and provide a specific individual who is responsible for the meal planning. Significant efforts have thus been put forward to improve the component that supply and logistics has in affecting underconsumption of the ration.

[3] A Rations are cook-prepared from fresh or perishable foods; B Rations are cook-prepared from canned or dehydrated foods.

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### Scenario in the Future

The plan for the future as described by CW4 Peter Motrynczuk (see Chapter 4 in this volume for summary) is to add three more cooks per battalion and to use all cooks in new ways. The plan is to put small mess teams forward; one of these two-person teams will be a soldier with a grade of E-5 with some cooking experience. They will do limited food preparation forward and will have equipment and support to do it with Kitchen Company Level Field Feeding-Enhanced (KCLFF-E) equipment and a high-mobility vehicle (HMV). The equipment forward includes a sanitation center (SC) with materials for preparation and cleanup of B and some A Rations. This center is a component of the mobile kitchen trailer (MKT) with a new container kitchen and a generator to minimize preparation time, to allow food refrigeration, and to permit water storage. Cooks remain in the battalion field training area to do food preparation. Equipment improvements will be made at this level as well.

It is hoped that by having the cooks forward with the assault companies it will be possible to customize food preparation to better fit troops' needs. This proposal is an example of tailoring both the food and the situation to each other, and then adjusting the fit.

*In summary*, proposed changes in the number and location of Army cooks and their support vehicles may greatly reduce the present logistical difficulties in providing hot meals to soldiers. The improvements outlined by CW4 Peter Motrynczuk are scheduled for implementation in early 1996 and will also allow increased use of a wider variety of food items, including fresh foods.

## PROPOSED PLAN OF ACTION BY NRDEC

The research proposal by Edward Hirsch (see Chapter 22 in this volume) is designed to show if certain manipulations in the way troops are fed in the field will lead to increased ration consumption. The proposed manipulations include using a new ration, premarketing the ration system, providing a social setting for the eating situations, and introducing more variety in the system. Other suggested manipulations are to prevent some of the trauma frequently associated with deployment, provide scheduled meals and snacks, create a protected environment for feeding, provide easy ways to heat the ration, and ensure adequate fluid intake. The proposal suggests that company-sized units might be exposed to the variable individually and food intake measured relative to energy expenditure. This demonstration would involve the use of approximately a battalion of troops and involve considerable data collection by a number of investigators. The CMNR is concerned that several of the proposed manipulations may produce an improvement, but provide little data as to whether or not implementation of these changes would result in adequate

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intake of the modified ration system. The incremental effects of any of these manipulations could not be adequately evaluated, and it might not be possible to recommend a field feeding system that did or did not provide assurance of adequate consumption to meet energy needs.

Instead such a program should first review the data on eating behavior from both military and civilian institutional studies. The best results from this review could be used to construct a multifactorial model concerning the importance of such variables as variety, meal schedules, snacks, feeding environment, social influences, and convenience of food preparation. Such a model would provide a basis for carefully controlled pilot studies to obtain a potential measure of the influence of these variables on intake. From these pilot studies, hypotheses could be constructed utilizing the most likely variables. Those variables that are judged feasible in a military operation could be more effectively tested. A multifactorial modeling approach could thus provide a rationale for obtaining military field test units. The resultant data could be used as a guide to field commanders in utilizing the strategies developed for a field feeding doctrine.

Although the Army has devoted a significant amount of effort to ration development, less consideration has been given to the effects of situational and environmental factors that may have a significant impact on consumption. The stressful environment of the field, particularly combat, certainly impacts on ration consumption, and there may be higher acceptance of certain ration items than others under those conditions. A program for marketing or educating soldiers about the military operational ration and its importance to their performance may be important, particularly when it is known that negative comments from peers, superiors, media, and others can help establish a negative image of military combat rations and thus discourage consumption.

Underconsumption of military operational rations may only be a problem if it has negative impact on physical and cognitive performance. Long-term or repeated usage of rations may result in more significant weight losses and thus may have the potential for larger effects on physical or cognitive performance.

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# 2

# Conclusions and Recommendations

As stated in Chapter 1, the Committee on Military Nutrition Research (CMNR) was asked to address five specific questions dealing with strategies to overcome underconsumption of military operational rations. The committee's responses to these questions appear below. These answers are further elaborated in the recommendations that follow. The conclusions and areas for research developed by the CMNR are also included.

## ANSWERS TO THE QUESTIONS POSED TO THE COMMITTEE

**1. Why do soldiers underconsume (not meet energy expenditure needs) in field operations?**

Ration factors, including palatability, variety, and temperature of the foods, are major contributors to general acceptance. Heavy activity or environmental extremes may increase energy requirements without compensating ration intake. Hypohydration may lead to temporary anorexia and a worsening cycle of lowered water and food intake. However, environmental or logistic components that are often under the influence or control of the command are

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also extremely important. These factors include such situational elements as designation of eating locations, meal schedules, social setting (alone or with others), and provision of rations at appropriate temperatures. The committee believes that multiple logistic, situational, and sensory factors contribute to decreased consumption. Military operational rations are by design all inclusive and do not allow substitution or choice. Failure to provide adequate time, instruction, and encouragement to eat and drink can materially influence consumption. The attitude of the local commander is critical in ensuring that soldiers are aware that daily adequate nutrition is important so as not to degrade performance over a period of time. It would be an important future research step to provide a priority order for the impact of these multiple factors on soldier food intake in the field.

**2. What factors influence underconsumption in field operations? Identify the relative importance of rations, environment, the eating situation, and the individual.**

A number of factors influence the quantity of operational rations consumed. Generally under field conditions, an underconsumption of rations is observed, which leads to weight loss. Numerous factors including the environment, the specific eating situation, the ration itself, and the individual can affect the amount of rations that will be consumed. Any one of these can be the most important factor depending on the situation. Further review of the relevant military data on eating situations that provides an integrated overview of the ordering of environment, the rations, and the individual factors with situational change would be beneficial. The following are reasonable conclusions/opinions based on available evidence:

> **Environment:** Field environments are generally harsh, frequently require increased energy expenditure, and are not conducive to the enjoyment of eating. Proximity to danger, temperature extremes, unappetizing local conditions, and lack of protection from the elements are all conditions that are encountered in a military scenario and can contribute to an impairment of appetite and underconsumption.
>
> **Eating Situation:** The opportunity for social interaction,information exchange, and appropriateness of meal to the time of day, are all elements of the eating situation that can contribute to food intake.
>
> **Rations:** Acceptability of rations to the soldier includes temperature,sensory properties (taste, smell, texture, color, and temperature), packaging,individual food preferences, ease of use, nutritional content, stability of product, appropriateness to time of day, delivery, presentation,

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availability, variety, and duration of reliance on operational rations as a major source of available food.

**Individual:** The individual soldier's attitude toward military feeding systems is an important determinant of ration consumption. The commander's attitude regarding the feeding system and his or her knowledge of nutrition may influence the soldier's eating behavior. Activities of the individual soldier, such as consuming adequate fluids,drinking when eating, taking advantage of opportunities to heat appropriate ration components, and snacking on certain ration items when opportunities permit, will enhance energy consumption and nutrient intake.

**3. At what level of underconsumption is there a negative impact on physical or cognitive performance?**

Underconsumption of fluid or working in hot environmental conditions, either as a result of protective clothing or atmospheric conditions, may result in weight losses of 3 to 5 percent in less than 48 hours and can significantly reduce physical and cognitive performance. Therefore maintaining adequate hydration is critical to maintaining performance.

Existing historical and experimental data indicate that decrements in physical performance begin in well-hydrated individuals when 10 percent or more of initial weight has been lost. Other studies suggest that losses as great as 15 percent do not result in decrements in physical performance, if lean body mass is preserved and if the weight loss is primarily from body fat stores. Similarly, decrements in cognitive performance appear to begin to occur when weight losses reach 10 percent of baseline. It is likely that greater losses of body fat will not affect cognitive performance, if lean body mass is preserved. There is only limited, well-controlled research available, however, that addresses this issue. With both physical and cognitive performance, the key factors that must be considered are the initial body composition of the individual and the rate of weight loss. Active military personnel who meet the height and weight standards for their age are relatively lean with some soldiers having as little as 10 percent body fat. Rapid weight loss (in excess of 2 lb/wk) in such lean individuals indicates significant underconsumption with regard to energy expenditure and can be expected to lead to decrements in performance.

Intakes of protein in excess of normal intake may help preserve muscle mass in circumstances of inadequate energy intake but will not totally prevent its loss. Adequate carbohydrate intake, particularly during or following periods of heavy physical activity, will aid in maintaining or restoring muscle glycogen and maintaining performance.

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**4. Given the environment of military operations, what steps are suggested to enhance ration consumption? To overcome deficits in food intake? To overcome any degradation in physical or cognitive performance?**

Adequate fluid intake to prevent dehydration is the first step to prevent or overcome deficits in performance since the consequences of dehydration are most immediate. In addition, as noted in the foregoing discussion, there are many other factors affect ration consumption in the environment of military operations. They include, but are not limited to, the nature of the rations; the eating situation in which such rations must be consumed; the environmental conditions that influence how, when, and under what physical conditions (i.e., temperature) the rations will be consumed; and the motivation provided the soldier to consume the food. To overcome possible effects of underconsumption on physical and cognitive performance, efforts should continue to increase the overall consumption of rations by military personnel in the field through a variety of approaches, which include establishing a *field feeding doctrine* at all levels within the command structure down to the individual soldier. Such a *field feeding doctrine* would include definitions of adequate food intake for soldiers in military operations and the potential consequences to performance and health of not eating enough. Steps to assure that soldiers have adequate intake should also be outlined in the food doctrine.

Military operational rations must be designed so as to protect body weight, especially lean body mass, by ensuring an adequate intake of energy, carbohydrate, protein, vitamins, and minerals. In considering the nature of the ration, continued effort to improve flavor, texture, and other organoleptic qualities should be pursued. The CMNR believes that current rations are of very high quality given what they are designed to do. Efforts to provide enhancements that will alter the flavor of entree items through the use of seasonings and other condiments should receive continued research and development. Use of newer processing technology should also be integrated into current rations to preserve greater texture of thermostabilized foods, which are packaged in flexible containers. Finally, research should be continued to provide greater stabilization of fat within other food components to reduce the appearance and mouth feel of greasiness in high-fat foods.

Although the extent to which the eating situation can be changed may be limited, making specific time available for eating is important and perhaps critical. Ideally soldiers should be able to eat in groups, and the opportunity to interact and share experiences should be provided when the tactical situation permits.

Steps should also be taken to cope with environmental factors that detract from food acceptance. For example, continued development of equipment for heating and preparing foods that can be used in remote locations and extreme environments, and improvement in individual equipment for preparing meals,

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should be undertaken. With indication from existing military and commercial research that "nibbling" can play an important role in overall energy intake, consideration should be given to the development of additional ration components that can be readily stored in pockets and consumed at a later time, especially high calorie and nutrient rich beverages of high acceptability.

Finally, steps should be taken to motivate soldiers to consume sufficient quantities of food to more nearly match their energy expenditures and maintain optimal performance. This motivation would be fostered by education and by encouragement through command leadership. The soldier should be provided information about the physiological and functional consequences of underconsumption of rations. Commanders should emphasize the quality of the food system and thereby create a positive image for the ration. The entire command structure should be involved in this effort. Special training on the importance of nutrition in maintaining physical and cognitive performance and morale should be provided to all command personnel. Platoon sergeants should be capable of informing their soldiers about their needs for adequate energy and water intake. The ultimate goal should be that ration consumption should be given equal priority to other training needs of the soldier.

The image of the ration both for the civilian and the soldier should also be improved. Current new endeavors incorporating humor with a nutrition and performance message into films appear to be a positive step if the impact of these films is carefully measured and the education message is retained. Changing the labeling of the individual food items will also be helpful. More information about the nutrient content and on alternative means of preparation of the entree should be included. Although outer packaging may have to comply with camouflage requirements, more colorful labeling of internal packaging would provide greater product appeal and relief from monotony.

**5. What further research needs to be done in these areas?**

This question will be addressed in the last section of this chapter, Areas for Future Research.

## CONCLUSIONS

### The Underconsumption Problem

Studies of field training exercises typically report underconsumption of military operational rations. Underconsumption in this context has been defined as an energy intake insufficient to meet the needs of the energy expenditure. The consequence is weight loss, with the amount of the weight loss being proportional to the underconsumption of energy from the ration. In six studies

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where the doubly labeled water method was used to measure energy expenditure, the Meal, Ready-to-Eat (MRE) intakes were compared with other ration combinations during field training exercises lasting from 10 to 30 days. An average underconsumption of approximately 1,552 kcal/d (range 520-2,199 kcal/d) relative to measured energy expenditure was demonstrated. All but one of these studies were conducted under conditions known to markedly increase energy requirements (BMR elevated 20–40 percent) and have shown energy consumption ranging from 52 to 85 percent of energy expenditure. In a series of short-term studies with research modifications of the MRE ration, there has been improved energy intake with each MRE version (for example, MRE IV and MRE improved, MRE VIII and supplement, etc.). However, it is not known if this increase is sustained over longer-term use in the field or represents a novelty effect. Both consumer and military research has indicated that some ration components such as bread, high-starch vegetables, and certain beverages can be expected to retain their high acceptance.

In contrast, limited studies using A Rations or mixed rations in field settings have shown energy intakes approximating energy expenditure (cf., Rose and Carlson, 1986). Therefore, it appears that under certain conditions, consumption of rations in the field can equal energy expenditure. It should be recognized that a comparison of field exercises that provide A Rations, which consist of hot and/or fresh foods, with those that supply only MREs represent measurement of ration acceptance confounded with other variables. Factors other than ration quality or food acceptance including food temperature and variety, as well as situational factors and logistics, can have a major impact on consumption of military operational rations.

### Potential Effects of Underconsumption on Performance

The significance of underconsumption, with its consequent loss in body weight, is its impact on physical and cognitive performance. The MRE studies show that while daily energy deficits of 1,000 to 1,500 kcal/d occurred, protein and other major nutrient intakes remained at basically adequate levels. Thus, during periods of from 30 to 42 days, deficiencies of nutrients other than energy are unlikely when consuming the MRE ration.

The rate of weight loss must be considered in addressing the potential impacts of underconsumption on performance. In physically fit and healthy troops rapid weight loss of 3 to 5 percent in less than 48 hours is primarily due to dehydration and can impact on physical and cognitive performance. Weight loss in excess of 5 percent in this time frame will most likely be associated with decreased performance and can lead to negative effects on health.

In initially well-nourished and properly hydrated troops, weight losses not associated with trauma or disease reflect the deficit in energy intake relative

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to expenditure. Therefore rapid weight loss (in excess of 2 lb/wk) indicates significant underconsumption of energy (1,000 or more kcal/d). A loss of 10 percent of body weight in a soldier of initial weight of 160 lb in just 4 weeks reflects a kcal deficit in the range of 2,000 kcal/d. If weight losses are modest in the range of 1 lb/wk the loss will primarily be from body fat. More rapid losses, particularly in lean individuals, will reflect a greater loss of lean body mass in addition to body fat. Weight losses primarily from body fat are not likely to reduce performance; however, as weight losses increase and an increasing percent of the loss is from muscle tissue, measured decreases in performance will occur as shown in the studies reported by Friedl (see Chapter 14 in this volume). Soldiers with lower body fat will more lean muscle mass from the beginning than those with higher fat reserves (Vanderveen et al., 1977). Given the individual variation in body composition of physically fit soldiers, it is not possible to specifically relate potential performance deficit to a specific percent loss of body weight, particularly in a period of 4 to 6 weeks. The problem is further complicated by the possibility of an individual, who may have lost 5 to 10 percent of body weight in a deployment, being redeployed before sufficient time to regain the lost weight. The individual will face a further weight loss with lower fat reserves and consequently lose lean body mass with even a relatively small loss of body weight.

Therefore it seems prudent to minimize body weight losses when possible during operations to maintain a high degree of fitness and performance. This may be particularly important in the current downsizing of the forces as units may be frequently deployed as the need arises in various parts of the world.

Very limited data are available on the impact of weight losses on cognitive performance. Closely related are potential mood or morale changes that may adversely affect cognitive performance. Therefore, careful attention to the weight changes in a unit during extended operational deployment is important to assure that operational capability is maintained.

### Strategies to Overcome Underconsumption

Underconsumption of military operational rations is undoubtedly a multifaceted problem:

- Ration factors, such as ration image, palatability of individual components, nutrient density, variety, meal and meal item appropriateness for the time of day, and fluid intake, contribute to the general level of acceptance.
- Situational factors, such as eating location, social setting, and allowing sufficient time to eat and drink during deployment and in the field, as well as appropriate meal scheduling with consideration of changes in circadian rhythms, are likely to be important.

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- Environmental factors, such as protection from heat or cold, ability to heat entree components or consume fluid products at appropriate temperatures, and the accessibility of fluids, influence food intake.
- Emotional state, such as feelings of security from enemy action, can affect appetite and ingestive behavior.
- Leadership issues, such as influence of the unit commander on soldier attitudes toward ration consumption, can be critical. Positive attitudes expressed by officers and noncommissioned officers can influence intake. Commanders may be influenced by effects of ration intake on morale and/or on physical and cognitive performance over a period of time. A subset of the leadership issue is individual soldier attitude.

An important step in developing strategies to overcome underconsumption of military operational rations is to analyze critically the available data. Such analysis should help identify the potential contribution of the factors outlined above to the underconsumption issue. This analysis will serve two important purposes. *First*, those factors relating to ration, situation, environment, and leadership that appear to bear the greatest impact within each category could be identified and quantified to the extent possible. Then a *field feeding doctrine* could be developed in which each of these major factors is quantified, enabling field commanders to make informed choices relative to the situations in the military operation.

Significant efforts on the part of the U.S. Army Natick Research, Development and Engineering Center (NRDEC) to improve the acceptability of rations, particularly the MRE, have resulted in a demonstrated improvement in intake in experimental field settings. The MRE has great flexibility in its pattern of use; for example, it can be eaten by the individual soldier while on the move, in isolation, and without heating. This scenario will likely result in the least favorable consumption of the ration. However, if the combat situation permits, combat units (squad, platoon, and companies) could be permitted to come together at a scheduled time to consume their MREs in a more favorable social and environmental situation. Given this context, MRE consumption is likely to be higher than when eaten in isolation, and the troops will remain in a potentially better nutritional condition for forthcoming operations.

*Second*, constructing a ration consumption model in which the incremental effects of the various factors that may influence intake relative to need are identified and quantified would help to delineate the state of current scientific knowledge. Gaps that exist (presumably with an indication of the relative importance of each to facilitate setting research priorities) could be identified and a research agenda developed. Information gleaned from this model would be an important step in developing a *field feeding doctrine*.

The development of the new concept in the Army Field Feeding System as outlined by Peter Motrynczuk in Chapter 4 would reduce the long-term dependence on the MRE and, at least in theory, overcome some of the

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concerns over the weight losses due to underconsumption observed in the field studies. The highly engineered MRE system has functioned very well in fulfilling the original concept of a highly portable, nutritionally adequate ration for use in the initial stages of a military operation. The decision by senior Army leadership to implement this new field feeding system will allow the availability of hot, prepared meals of more traditional foods when appropriate for the tactical situation. Not only will the rations be more similar to traditional foods, but the eating environment will often be more conducive to greater food intake. Current food technology, packaging, and distribution technology, coupled with efficiently engineered preparation and distribution, should give the combat soldier more acceptable rations in most environments.

Moving in the direction of supplying hot meals whenever possible, including in the field, is an important strategy for overcoming underconsumption and improving morale. However, the MRE may still be used in initial combat operations for varying periods of time to a maximum of 21 days (U.S. Department of the Army, 1995), and data of the type suggested above would be valuable during that initial period. In addition, there are likely to be situations where operational and logistical constraints may require extended use of MREs or related systems. Therefore it seems useful to evaluate those factors that may optimize the MRE system to better meet the nutritional needs of the soldier under these potentially adverse conditions.

## RECOMMENDATIONS

The goal of field feeding is to provide sufficient water, food energy, and nutrients to maintain the soldier's hydration status, body weight, and lean body mass. A *field feeding doctrine* should be crafted that incorporates the types and amounts of food offered, issues related to environmental extremes, and actions to be taken with excessive weight loss in the field. From a policy standpoint, the risks that energy deficits will be compounded by uncontrollable events in combat are considerable, and thus any consumption deficits are undesirable. The guiding principle of this *field feeding doctrine* is that the energy intakes of military personnel during training and combat operations should be adequate to meet their energy expenditures. The level of individual body weight loss should determine the actions to be taken. Suggested criteria for assessing whether energy consumption is adequate to meet energy expenditures for individual soldiers are provided in Table 2-1. Moreover, as suggested by Schnakenberg (see Chapter 6 in this volume) the appropriate criterion to evaluate whether troops are eating enough of their ration to meet their energy demands should be that the average body weight loss of the test unit does not exceed 3 percent of initial body weight over a period of several weeks.

While underconsumption of operational rations in the training environment is not likely to result in significant reduction in physical or cognitive performance,

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it may be indicative of a more severe problem when soldiers are under the extreme stresses of impending or actual combat. Therefore steps to minimize underconsumption in training environments may be important when the stress of actual combat operations are imposed.

TABLE 2-1 Likely Causes of Weight Loss and Potential Impact on Performance*

| Average Body Weight Loss | Time Period | Likely Cause | Potential Performance Impact |
|---|---|---|---|
| <3% | 24 hours | Inadequate fluid intake | Unlikely |
| | 24 hours-4 days | Energy deficit | Unlikely |
| >3%<10% | Less than 48 hours | Principally inadequate fluid intake | Highly likely, particularly cognitive deficits |
| | 3 days-4 weeks | Energy deficit | Unlikely |
| >10% | Less than 48 hours | Inadequate fluid intake | Serious deficits |
| | 3 days-12 weeks | Severe energy deficit | Very likely |
| | 12 weeks or more | Energy deficit | Unlikely |

* The performance deficits shown in this table will be influenced by (a) the initial body composition of the individual; (b) the speed of weight loss; (c) the composition of the loss (i.e., water and electrolytes, lean body mass, and fat); (d) the presence of trauma, infection, or illness; and (e) the tests being used to measure performance decrements.

Since there is evidence that the provision of A or B type rations in training environments does more nearly match energy intake with energy expenditure, it seems important to evaluate the new Army Field Feeding System under operational training environment as early as possible. If this system succeeds in minimizing underconsumption during these training exercises, the focus of research on MREs, T Rations, and other operational rations could be related to evaluating factors that in the short term (3–21 days) may enhance ration consumption or enhance performance in stressful environments.

## THE COMMITTEE ON MILITARY NUTRITION RESEARCH ALSO RECOMMENDS:

1. Even short term deprivation of food intake can lead to performance deficits due to the unpredictable stress of field training, combat situation, hypohydration, and environmental extremes. Every effort should be made to keep soldiers well hydrated to avoid hypohydration-induced anorexia. The goal should be to have individual energy intakes match energy expenditures and thereby provide sufficient food in a manner that encourages soldiers to meet their needs.
2. A field feeding doctrine analogous to the highly successful water doctrine, which highlights that food is the fuel of the soldier, should be considered. Such a doctrine will provide guidance to military commanders. In the doctrine an outline of factors that will tend to reduce ration consumption and possible steps to correct these conditions can be useful in helping to ensure that top-notch performance is maintained.

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3. Because the MRE will continue to be the ration used initially in most military operations, continuing effort should be made to enhance its consumption. Recommended changes include improved individual items including the addition of carry-away snack items, greater variety and enhancements to reduce monotony, improved packaging, better labeling, and creative marketing/training in the importance of the ration and its use.
4. Unit commanders should be informed of the potential consequences of weight loss due to dehydration as indicated by a rapid weight loss (2–5 percent in 24–48 hours) or the longer-term effects of underconsumption of rations and should monitor their units to ensure this underconsumption does not adversely affect performance especially during combat. Whenever possible, monitoring should include periodic body weight measurements and other simple anthropometric measures feasible in the field. As a minimum, body weight measures should be done routinely as part of deployment and return activities. Weight losses in the range of 10 percent in operations extending over 4 weeks raise the concern of reduced physical and cognitive performance and have possible health consequences in some of the individuals in the unit.

   Since data indicate that the addition of fruit-flavored drinks and flavored shakes with caloric sweeteners to more recent versions of the MRE has led to increases in total energy intake, the CMNR recommends that these items continue to be included in the overall menu program. Further, substitution of existing beverages with artificially-sweetened products may prove counterproductive.
5. Unit commanders should be provided guidance as to ways of minimizing the adverse effects of the field environment (e.g., inclement weather, unappetizing local conditions, and lack of congregate meal times) on consumption where possible. This training would improve ration consumption and thus help to minimize performance decrements. The impact of inadequate fluid and food on physiologic function and performance should be emphasized to commanders in light of their importance as role models for increasing soldier food intake.
6. Foods provided as snacks can be an important source of energy and other nutrients. Such foods could be provided as part of the MRE or as additional food items.
7. A guide should be prepared for commanders in which the impact of various factors involved in food consumption and performance is summarized, based on currently available data. Unit commanders can use such a guide to assist them in making informed decisions concerning the need to improve feeding scenarios during military operations. Such a guide could indicate when changes were needed to avoid possible decrements in unit performance.

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8. Continued efforts in the development of promotional materials to improve the image of military operational rations, such as the films shown at the workshop, are encouraged. Tied to this effort should be a careful research plan that measures the impact of these materials on soldiers' attitudes.

## AREAS FOR FUTURE RESEARCH

The information in this report is primarily derived from data collected during field training exercises. While these observations are important, the impact of the actual exposure to the stresses of combat or impending hostile action is certainly likely to be much greater. Carefully evaluated feedback from soldiers who were deployed in operations such as Vietnam, Desert Storm, and possibly Somalia and Panama could add further insight and realism to the possible extent of underconsumption and influencing factors (e.g., the degree of anxiety, fear, and climatic condition) that would go beyond the information obtained in training exercises. Information on the coping mechanism used by soldiers under these conditions may be useful in considering how to overcome these problems and suggest important areas for research.

The Committee on Military Nutrition Research recognizes the concern that the loss of weight by personnel during training and operations poses to the military. The scientists at the U.S. Army Research Institute of Environmental Medicine (USARIEM) and U.S. Army Natick Research, Development and Engineering Center (NRDEC) have conscientiously followed this issue and conducted carefully planned research programs that have evaluated the impact of food-intake patterns on performance and the factors influencing food intake. The following are suggested by the CMNR as future areas for study that would build on this excellent research base:

- Follow-up interviews with soldiers who participated in Operation Desert Storm that include direct questions about weight loss, food intake, and appetite as well as questions about food items and situational factors would be an important step in interpretation of experimental data. For example, did you lose weight? How much weight? Were you overweight at the start? Why do you think you lost weight? How did you feel about the weight loss? Did you want to lose weight?
- More data on food acceptability under actual rather than simulated field conditions should be collected. This data collection should include both rating scales as well as actual consumption data.
- Focus group research should be carried out with current troops, including women, and with combat veterans with questions directed toward feeding systems in the field including the questions related to MRE packaging, menu items, criticisms, and suggestions for improvement.

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- Practical measures should be created to develop, test, and refine a "field feeding doctrine" as described earlier in this report. The food doctrine would be analogous to the successful water doctrine currently in use.
- A simple system should be developed and field tested to monitor body weight and body composition of troops before and after deployment. This system could be used in all field conditions including combat operational training.
- Additional field studies should be conducted that monitor energy intake and energy expenditure using doubly labeled water measurement techniques in temperate and hot environments for comparison with the six existing studies conducted in cold and high-altitude environments. Body composition measures would also be desirable if simple methods were used.
- The relationship between hydration and food intake in military field settings bears additional, carefully designed research.
- The committee believes the existing research on food intake, performance, food item preference, and eating situational factors would first of all benefit from a thorough, careful cross-study integration and interpretation. A multifactorial computerized research model that incorporates the most pertinent findings should then be compiled. This model can be used to assist with the generation of specific hypotheses for future studies, and may be used for selected meta analysis where appropriate.
- Identification of critical and appropriate physical and cognitive tasks, and careful measurement of performance during field operations or recruit training when weight loss is anticipated, would assist in further quantifying the relationship between underconsumption and performance.
- Future field studies should address the question of MRE food item wastage as it relates to specific nutrient intake in relation to energy intake and expenditure.
- The influence of menu variety on intake needs to be tested over a period of time. Carefully designed menu rotation studies that incorporate current understanding of the impact of variety, sensory specific satiety, temporal habituation patterns, energy density, the fat and fiber content of foods, and palatability on intake and body weight could provide directly relevant information.
- A brief study that systematically administered ibuprofen to troops in field exercises could provide information on a potential generalized stress/cytokine/food intake mechanism.
- All future research studies and focus groups should include women and combat veterans where feasible.

**The committee commends the development of Kitchen Company Level Field Feeding-Enhanced (KCLFF-E) equipment and the concept of having cooks forward with combat units. After implementation, this system**

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**requires follow-up evaluation as to its effectiveness and ways it can be improved.**

The CMNR believes that the military services, through their pool of volunteer personnel, offer an excellent and often unique opportunity to generate research data and statistics on the nutrition, health, and stress reduction in service personnel. These findings can be directly applied to improving both the health and the performance of military personnel and those of the general U.S. population.

The Committee on Military Nutrition Research is pleased to participate with the Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine, U.S. Army Medical Research and Development Command, in programs related to the nutrition and health of U.S. military personnel. The CMNR hopes that this information will be useful to the U.S. Department of Defense in developing programs that continue to improve the lifetime health and well-being of service personnel.

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# Part II

# Background and Introduction to the Topic

IN PARTS II THROUGH V THE PAPERS from workshop appear in the order in which they were presented. The chapters have undergone limited editorial change, have not been reviewed by an outside group, and represent the views of the individual authors. Selected questions and the speakers' responses are included to provide the flavor of the workshop discussion.

Part II includes six chapters based on the introductory presentations by current and former Army scientists and personnel. Chapter 3 presents the purpose of the workshop and report from the perspective of one of the lead scientists who has extensively studied soldier intake patters, with emphasis on the individual, the food, and the eating situation or environment. The majority of the chapter further provides an overview of the remainder of the report and how each author approaches the problem of underconsumption of military operational rations.

To frame the problem of ration underconsumption, the context of the field feeding system is described in Chapter 4. Operation Desert Storm raised questions regarding the acceptability of the current Army Field Feed System (AFFS) and its ability to move rations to the forward line of troops. To remedy this field scenario, the U.S. Army Quartermaster Center and School (QMC&S) conducted field trials to test the Army Field Feeding System-Future (AFFS-F). The AFFS-F will add new equipment and trained personnel to military field feeding. One of the most noteworthy improvements is the addition of the Kitchen Company Level Field Feeding-Enhanced (KCLFF-E) equipment, which moves forward with the company mess, and can be used to heat food

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while it is being served and keep perishable foods fresh. In addition, cooks are again moving forward in the field, and each brigade service area will have a brigade foodservice warrant officer to coordinate the food plans with the demands of the field situation.

Commanders' perceptions and attitudes about field feeding are the subject of Chapter 5. Survey results from the Army War College show the varying levels of nutrition knowledge and education among commanders. Many report that the training scenario dictates eating decisions and that their nutrition knowledge is limited. The survey highlights how the relationship between nutrition and performance is not well understood among military officers.

The section continues by explaining the military operational ration system and its continuing development and improvement in Chapters 6 and 7. From the historical perspective of developing and testing rations, the author of Chapter 6 concludes that the Military Recommended Dietary Allowances (MRDAs) are the appropriate criteria for nutritional adequacy of intake in the field. Continued ration evaluation will indicate if nutrition criteria are met. Chapter 7 delineates the numerous constraints to ration development and describes the five military operational rations (Meal, Ready-to-Eat [MRE]; A, B, and T Rations; and Unitized Group Ration [UGR]) in detail. The authors conclude that a self-heating group meal ration system will be an important component of any future field feeding system.

In the final two chapters, data from ration studies conducted in the field are summarized. Using field tests conducted by the Military Nutrition Division at the U.S. Army Research Institute of Environmental Medicine, Chapter 8 shows that, in general, the lower energy intakes of the field do not meet the higher energy requirements, resulting in variable weight loss during military operations. Chapter 9 reviews the research data on improvements to the MRE and T Ration in terms of ration intake and its acceptability to soldiers. The author closes by observing that, in general, a change in at least 15 percent of a ration's items is enough to produce an increase in energy intake and an improvement in the perception of food quality.

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# 3

# Introduction to the Concepts and Issues Underlying Underconsumption of Field Rations

*Herbert L. Meiselman*[1]

## INTRODUCTION

The overall purpose of the workshop from which this book was developed was for the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Natick Research, Development and Engineering Center (NRDEC) to ask the Committee on Military Nutrition Research for assistance in developing and assessing a strategy. Researchers at USARIEM and NRDEC have identified a problem: underconsumption of military rations. They recognized that this problem is important to the military and to the general research community, which is interested in why people eat and why they do not eat. Researchers at NRDEC have identified possible solutions to the problem. It is now time to review the problem and the proposed solutions to ensure full consideration of the approach, the data, and other alternatives.

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It has been difficult to gain a perspective on recent research because so much of the research on human eating focuses on the individual and the food. This report also treats the individual and the food, but will add an important third dimension, the eating situation or context. These three factors together are necessary to understand why soldiers eat or do not eat, and they must be considered and addressed to improve the current situation. Below is a brief outline of how the meeting and the book were conceived and developed to fully cover these three topics and other important issues.

Interest in what goes on in the field regarding Army personnel and rations and whether there is a problem of underconsumption began in 1983 with the first extended, comparative test of a field ration. NRDEC conducted a 34-d test, with one group receiving 3 Meals, Ready-to-Eat (MREs)/d providing 3,600 kcal and a control group receiving 2 fresh meals and 1 MRE/d providing the same number of calories. The MRE group ate an average of 2,189 kcal over the 34 days, but their caloric intake continuously declined over that period, ending at 1,681 kcal. Soldiers lost an average of 8.11 lbs (3.7 kg) (4.7 percent body weight), with some individuals losing up to 11 percent body weight. The soldiers rated their food 7.05 on a standard 9-point hedonic rating scale (Hirsch et al., 1985).

At about the same time, a study was conducted with a comparison group of young males (university students at the Massachusetts Institute of Technology [MIT]) consuming MREs. Participants received either 3 MREs/d or freshly prepared food for 45 days. Of course, the students did not receive their food out-of-doors as the soldiers did. The students had tables and chairs, set mealtimes, tableware and dishes, and the ability to heat food. The MIT students averaged a daily caloric intake of 3,149 kcal over the 45 days. Their caloric intake also declined over the 45 days. They lost a little weight (average, 1.5 lbs [0.7 kg] or 1 percent body weight). They rated the food 6.05 on the standard 9-point hedonic rating scale (Hirsch and Kramer, 1993; Kramer et al., 1992).

It was not clear during initial comparisons of the soldier study and the student study what was responsible for the 1,000 kcal difference in intake and the 1.0 difference in acceptance ratings. Soldiers rated their food higher but ate less; students rated their food lower but ate more. During analysis, the food and the individual were considered first; then it became apparent that the eating situation should be examined.

The analysis had begun to develop further when a paper for the 1987 meeting on food acceptability was published, stating that "field studies have led us to conclude that important factors controlling consumption of food in natural eating situations are the situational variables which make it more or less convenient for us to eat and which signal meal times" (Meiselman et al., 1988, p. 77).

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Today, there is a data base of 15 studies conducted by USARIEM and NRDEC. These studies show an unchanging pattern of ration consumption and ration waste in which these two factors appear to account for two-thirds and one-third of what is provided, respectively (Figure 3-1). What has also begun to emerge is that eating in the field and eating in dining rooms produce different food intakes and different patterns of food acceptance (see Baker-Fulco, Chapter 8 in this volume) (Table 3-1).

The chapters that follow provide baseline information on what happens in U.S. Army field feeding. During the workshop, Peter Motrynczuk of the U.S. Army Quartermaster Center and School discusses the present and planned future concepts for how to feed the Army in the field. A summary of his presentation is included as Chapter 4. Celia F. Adolphi of the Department of the Army presents the views of commanders on troop feeding and nutrition obtained at the Army War College in Chapter 5.

The next two chapters cover what should be consumed and what is provided. David D. Schnakenberg reviews the history of nutritional criteria for feeding the Army and specifically details the current nutritional criteria for

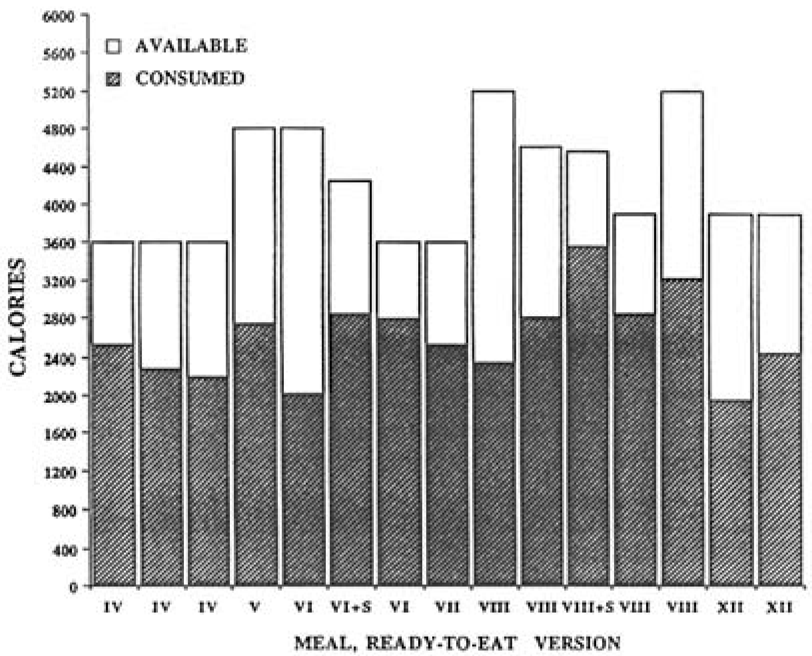


**FIGURE 3-1**
Average calories available and consumed in Meal, Ready-to-Eat (MRE) field tests.

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rations in Chapter 6. Gerald A. Darsch, who heads the Sustainability Directorate at NRDEC, and Philip Brandler cover the history of MRE development and plans for future ration development in Chapter 7.

TABLE 3-1 Consumption and Acceptance of Army Packaged Field Rations

| Field | | Garrison | |
|---|---|---|---|
| (kcal) | Hedonic Rating | (kcal) | Hedonic Rating |
| 2.189 | 7.05 | 3,149 | 6.50 |
| 2.876 | 6.90 | 3,848 | 6.30 |

Finally, the statement of the current situation is completed with two chapters on what soldiers eat in the field. Carol J. Baker-Fulco, USARIEM, summarizes a number of ration studies in a variety of environments (see Chapter 8 in this volume), and Edward Hirsch, NRDEC, summarizes studies of ration changes in the field (see Chapter 9 in this volume). Hirsch's review of ration acceptance and consumption parallels Darsch's review of the history of ration development.

Part III considers the food. Armand V. Cardello, a psychologists at NRDEC, presents research findings on product image, emphasizing the role of consumer expectations in Chapter 10. This research raises the important question of whether one should consider expected acceptance rather than the traditional measures of actual acceptance. Barbara Rolls of The Pennsylvania State University reviews her research on sensory-specific satiety and its implications for meal variety and dietary variety (see Chapter 11 in this volume). This and related research have led to the conclusion that food variety is a complex phenomenon; simply adding more choices does not necessarily add more variety. Rolls also focuses on the issue of portion sizes and snacks.

Dianne Engell, a psychologist at NRDEC, examines the important role of water intake in ration consumption in Chapter 12. Engell makes the important points that most water is consumed at mealtimes (i.e., with foods), many calories are consumed as liquids, and people without adequate water eat less food. All of these illustrate the critical role of liquids and hydration. The problem of underconsumption of rations cannot be understood or solved without considering liquids.

Eileen G. Thompson, former Marketing Research Director of Quaker Oats, provides an industry perspective on food issues in Chapter 13. Some of her points reinforce material presented elsewhere in this volume (e.g., liking is not a univariate problem; visual appeal and naming are critical), while other points are uniquely her own (e.g., critical role of complex seasoning; how testing methodology affects seasoning choice).

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The current state of research on how food and food acceptability affect food selection and intake is indicated by the chapters in Part III. These data clearly indicate that the field is not ready to entirely refocus on nonfood factors to understand why people eat. There is a great deal more to learn about the important issues of food variety, food portions, food seasoning, and food presentation.

The next three chapters that comprise Part IV provide state-of-the-art answers to the question, "So what?" Given that soldiers underconsume, what are the implications for their physical and cognitive performance and for their overall medical well-being? Karl E. Friedl, from the Army Operational Medicine Research Program at the U.S. Army Medical Research and Materiel Command and formerly from USARIEM, surveys the data to date in a series of rugged field tests (see Chapter 14 in this volume). Friedl identifies what might work as a performance indicator (lift capacity), what is less likely to work as an indicator (handgrip strength), and what level of underconsumption is needed to observe physical performance changes. Mary Z. Mays, also from the U.S. Army Medical Research and Materiel Command and formerly from USARIEM, reviews cognitive performance, emphasizing methodological issues (see Chapter 15 in this volume). Both papers conclude that weight loss of 10 percent or greater needs to be reached before performance impairment is observable, but both papers raise serious methodological questions. It appears that until it is settled how to conduct such studies (choice of subjects, tasks, measures), the "So what?" question cannot be definitively answered.

To conclude Part IV, Stephen Phinney from the University of California, Davis presents a broader medical view of energy imbalance, using examples from sports medicine rather than from military field studies in Chapter 16.

Part V deals with the eating situation, including both its physical and social aspects. F. Matthew Kramer from NRDEC reports on the eating situation as studied at NRDEC, as well as other research on this topic in Chapter 17. Howard G. Schutz from the University of California, Davis provides a method for including situational effects in attitudinal research (see Chapter 18 in this volume). His appropriateness scaling focuses on contextual issues instead of the usual sensory and hedonic focus. Franz Halberg, of the University of Minnesota, with Erhard Haus and Germaine Cornélissen, extends situational considerations to the broad issue of biological rhythms and chronobiology (see Chapter 19 in this volume). Finally, John M. de Castro from Georgia State University presents his extensive and compelling data on social facilitation of eating in Chapter 20. The dietary intake data he has collected clearly display the profound effect on eating in the presence of other people, a key issue in designing proper field feeding for soldiers who often eat alone or on the run.

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John P. Foreyt, G. Ken Goodrick, and Jean E. Nelson of the Baylor College of Medicine then attempt to put underconsumption within the context of clinical underconsumption, that is, eating disorders. They explore whether eating disorder paradigms are relevant to reduced eating in nonclinical populations.

All of the above chapters identify food consumption in the military within a very broad context in which both the food and the physical and social environments exert influences. Given the military feeding environment described in early chapters, one needs to ask what can be done to enhance ration consumption by soldiers in the field. More broadly, how can eating be enhanced in general? This is an unusual question for most Americans, who are more familiar with the goal of reducing food intake.

Also at the workshop, but not included in this volume, was a panel discussion where a number of different perspectives was provided on how to enhance ration consumption. Panelist Robert Smith of Nabisco presented a customer-oriented perspective from industry. His remarks covered both product and marketing issues and heavily emphasized the soldier as customer. Howard Moskowitz, who worked at NRDEC years ago and now heads a market research firm, stressed that new technology should be used to focus on metafeatures or broad concepts in foods, not simply food products and eating situations. Cheryl Achterberg from the Nutrition Department of The Pennsylvania State University isolated a number of points raised during the meeting, such as food novelty and variety and nutrition education. She also raised the issue of marketing and treating the soldier as a customer. Achterberg drew comparisons between the military situation and the school lunch situation. Robin Kanarek of Tufts University reviewed material from the other chapters and also stressed food novelty, availability, and appropriateness.

Finally, Edward Hirsch of NRDEC presents a draft NRDEC plan in Chapter 22 that outlines an attempt to modify the military field eating situation. Hirsch's proposal is still being developed. One goal of the workshop was to re-evaluate the field feeding situation from a broader perspective in order to identify the most likely areas for improvement and fruitful research. Another goal was to share the large volume of relevant research among government, academia, and industry. It is hoped the reader will find both goals were realized.

## ACKNOWLEDGMENTS

I would like to thank the people who made this meeting possible. COL David D. Schnakenberg (Ret) and COL Eldon W. Askew conceived of this topic for a meeting of the Committee of Military Nutrition Research of the

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Food and Nutrition Board. The staff of the Food and Nutrition Board did an excellent job with arrangements. The technical staff at the U.S. Army Natick Research, Development and Engineering Center who were speakers (Drs. Hirsch, Engell, Kramer, and Cardello) provided numerous recommendations to build an outstanding program.

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## DISCUSSION

PHILIP BRANDLER: You show the garrison figures, the field figures, and the reverse relationship essentially between acceptance and consumption. Have the data been analyzed to see if the acceptance model does in fact work with a constant situational environment? That is to say, given the choice between two entrees and a field environment, does acceptance lead to greater consumption even though the consumption level itself might be different, and it might be in a different situation?

HERBERT MEISELMAN: I do not know if Armand Cardello is going to cover that.

PHILIP BRANDLER: Will he talk about acceptance?

HERBERT MEISELMAN: Probably not as it relates to consumption.

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PHILIP BRANDLER: I think the acceptance model will work in a simple comparison like that, but when you also change the situation, I don't think it will work.

HERBERT MEISELMAN: I agree with that, in relation to the data. The concern I have is that, in many cases, particularly with field rations, our basis for decision making is based on acceptance data. With a particular field environment we use acceptance data to select what we put into or remove from a ration. So if the acceptance model fails completely, we are using the wrong criteria.

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# 4

# Army Field Feeding System-Future

*Peter Motrynczuk*[1]*, with Bernadette M. Marriott*

## INTRODUCTION

### Background

The current Army field feeding policy was in place during Operation Desert Storm. This policy states that the Army is to provide soldiers with three quality meals per day. The responsibility for meeting this policy lies with the commander. This standard was typically met by providing soldiers with one Meal, Ready-to-Eat (MRE) and two Tray rations (T Rations) per day, with one A or B meal[2] every third day. This meal configuration was supplied to the commanders during Operation Desert Storm.

[1] Peter Motrynczuk, Army Center of Excellence, Subsistence, U.S. Army Quartermaster Center and School, Fort Lee, VA 23801-5000

[2] A T Ration is a group ration that consists of heat-and-serve prepared foods in half-steam-table-sized rectangular cans. A Ration meals are fresh foods; B Rations include the semi-perishable and dehydrated foods. For a more detailed description, see Darsch and Brandler (Chapter 7 in this volume).

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After Desert Storm (and even during Desert Storm), senior leaders suggested that this was not acceptable for the soldiers. In particular they indicated that there needed to be more cook-prepared meals. To maintain morale the leaders said that soldiers needed "…to smell the bacon and coffee brewing in the morning." As a result, the U.S. Army Quartermaster Center and School (QMC&S) was directed to conduct an Army-wide study. A study of the Army Field Feeding System (AFFS) began in March 1991 to develop an AFFS strategy for the future. The QMC&S conducted the field trials and established an independent evaluation effort called *Army Field Feeding System—Future Concept Evaluation Program Data Collection Effort* (AFFS-F) to validate the future strategy. The study concluded on June 2, 1992, and the results were presented to the Army Chief of Staff.

The main recommendation from the study was that soldiers should be provided with at least one A or B cook-prepared meal daily. This recommendation was stated as Mission, Enemy, Troops, Terrain, and Time (METT-T) dependent, which means that a commander is expected to follow this meal plan if the tactical and logical scenario allows. The Army Chief of Staff approved the concept, which resulted in increases in personnel, new equipment, and changes in the ration concept. The concept was approved contingent upon its validation with active Army divisions and a reserve component division to ensure that the concept is realistic and effective.

Four field validation trials were conducted to evaluate the AFFS-F under four conditions (heavy, light, airborne, and air assault organizations):

- December $1$2$30, 1992, 82d Airborne Division field trial;
- March 1$1$2$35, 1993, 24th Infantry Division (Mech) field trial;
- April 1$1$2$38, 1993, 101st Airborne Division field trial; and
- June 1$1$2$38, 1993, 49th Armored Division, Texas National Guard field trial.

The results were positive throughout. This new concept for a field feeding system is expected to be initiated as early as January 1996.

## AN ILLUSTRATION OF ARMY FIELD FEEDING[3]

In Figure 4-1 an Army division is schematically arrayed on a battlefield. The division boundaries are identified, and within the division boundary there

[3] During the workshop, the audience joined CW4 Motrynczuk around a three dimensional model of a mechanized infantry brigade. This model allowed the workshop participants to clearly visualize how the various Army units were fed on the battlefield.

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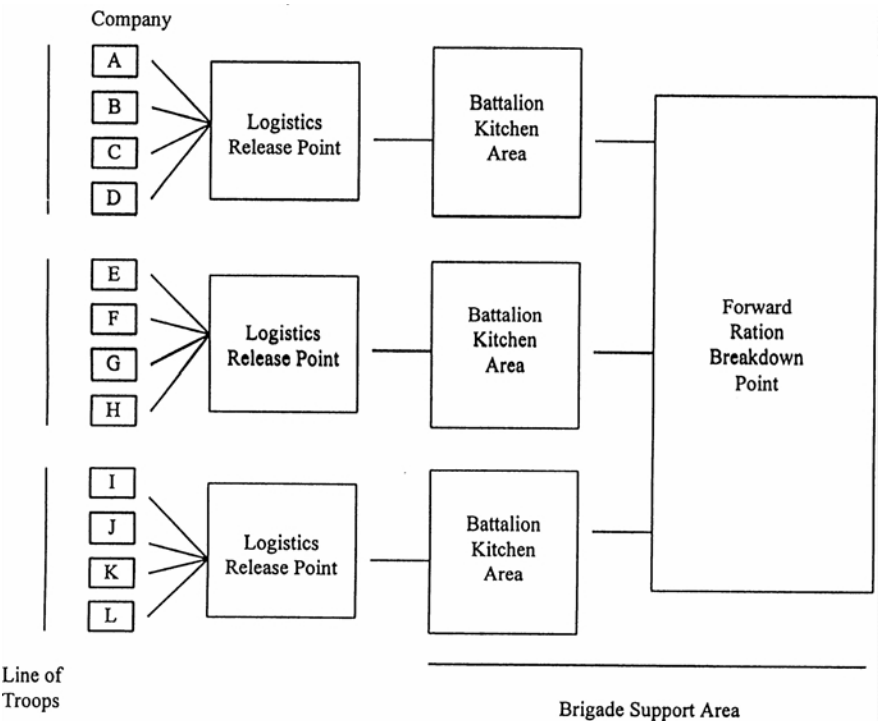


**FIGURE 4-1**
Schematic diagram of a mechanized infantry brigade illustrating the present Army Field Feeding System (AFFS).

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is a brigade support area (BSA) that typically is found to the rear of the troops where the soldiers are hypothetically engaged in battle. The approximate travel time between the two areas is typically 1 to 2 hours, but possibly longer.

The BSA includes all support facilities, including the battalion field kitchens. At the kitchens the large pallets containing rations are disassembled, and the food is prepared. Figure 4-1 and the following description provide an overview of how a typical mechanized infantry battalion would feed its soldiers that are forward of the line of troops, which is where the soldiers are fighting.

This chapter will begin with a discussion of how such a battalion would be fed by current Army doctrine and what is actually often taking place, beginning with the BSA at the rear and advancing to the forward line of troops. Subsequent sections will present a description of how the newly proposed Army Field Feeding System would solve some of the existing difficulties of Army field feeding.

## The Current Situation

Once rations are issued, there is a core support group that organizes and moves the rations to a forward ration breakdown point. The forward ration breakdown point is within the brigade support area (BSA). The core support may be 2 or 3 hours behind the divisional boundary which is therefore a significant distance away from the forward ration breakdown point.

At the forward ration breakdown point, rations are disassembled into unit piles, and then the unit foodservice sergeant or his designated representative will use a 2.5- or 5-ton truck to repeatedly traverse the distance from the forward ration breakdown point to the battalion field kitchen area, which may be an hour away, in order to retrieve one or more days' rations or food items.

The battalion field kitchen area includes the kitchen, cooks, and sanitation equipment, where food is prepared for the typically 500 to 700 soldiers in a battalion task force. The kitchen includes a staff of 17 cooks, 3 mobile field kitchen trailers, 3 sets of sanitation equipment, and the mess kit laundry lines, which have been in the system since the 1940s. Also included are the Kitchen Company Level Field Feeding (KCLFF) equipment that are used primarily to heat T Rations, which are essentially large cans that can be put into boiling water and heated, with the contents being served directly to a group of soldiers from the large tin or "tray."

Once the kitchens have the food, it is prepared, cooked, and packed into food containers to move forward to the soldiers. This typically occurs as part of a daily logistics package. A logistics package is the ammunition, food, fuel, and everything else that sustains the soldiers for another day or day and a half. In terms of timing, for example, if the daily delivery is an evening logistics package, the trucks will move forward at about 2:00 in the afternoon.

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Consequently the kitchen staff must have the food cooked and packed at 1:00 or 1:30 p.m. Unfortunately, the soldiers may not actually receive the food until 8:00 or 9:00 at night.

The food is thus prepared, cooked, packed into containers, and loaded on a 2.5-ton truck to become part of a logistics package that will move forward for an hour or more to an area called the logistics release point. This area is a centerpoint between the BSA and the forward line of troops. The logistics package will be met by a unit representative, normally the company first sergeant. Each company first sergeant will take their portion of the logistics package forward to their company, and they will make further distribution of the food, fuel, and ammunition to their platoons, tanks, and/or soldiers in the foxhole.

## Deficiencies in the Existing System

Food is prepared, packed, and sent forward of the line of troops, and then it is further distributed to the soldiers. Some of the problems associated with this system are time, utensils, and preparation.

For time considerations, it may be as much as 6 or 7 hours from the time that food is cooked and packed until it is received by the soldiers. For food in a container, 4 hours is about as long as it will retain its temperature; beyond that, the food becomes unacceptable. Part of the problem is that the soldier does not complain. The young soldier normally accepts this as a fact of Army life and continues with the mission. Delivery of food in this inappropriate condition is unacceptable and should be corrected.

Another problem is the ability to prepare the food items properly when they are received at the forward positions. If soup is provided as a warming beverage, there is no one to heat the soup, to make the coffee, or to complete similar preparations. These items move to the forward lines as part of the logistics package, but they are cold when received. This simple problem needs to be corrected.

Another point to consider is that the individuals who serve the food in the forward areas are not trained foodservice personnel. Cooks are no longer sent forward with the logistics package to feed the soldiers. The first sergeant or platoon sergeant will identify someone and charge them with the task of feeding the soldiers. From day-to-day the individuals selected to serve the food vary and may be truck drivers or supply clerks, for example. Often they do not have any understanding of how to prepare or serve the food.

As an example, in one November field setting, the food arrived at the company area at 10:00 at night. The T Rations had been in the containers for over 6 hours since their original heating. At this time of night in November the food was left open, and nothing was kept hot. Unless the soldiers were among the first few people in the line, they did not get a warm meal, and as a result,

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the soldiers did not eat the food. In this particular situation, there were no tables so the T Rations were placed directly on the ground. There were also no serving utensils, so the food was ladled with paper cups. Circumstances such as these make food very unappetizing. Also the individual may take the food because the first sergeant is there watching as people go through the line, but that does not mean that the food will be eaten. In this type of situation when the appropriate facilities were not available, the soldiers should probably have been given MREs instead of the lukewarm or cold T Rations. However, the server did not have the background, knowledge, or authority to make this decision, and if MREs were served, the company then may have been faced with a ration shortage prior to the arrival of the next logistics package.

An additional issue was that the T Ration was not the best ration for this military action scenario. This was a maneuver phase. There were then fire missions throughout the night. The most suitable ration probably was the MRE. This situation further illustrates the outcome of food being sent forward without trained foodservice personnel to evaluate the military scenario.

In Korea with the Second Infantry Division there was a similar problem. The person tasked with serving the troops did not know what food components to serve together. Consequently, some of the meals were missing food components. Some meals did not include the meat entree, and others included two meat components and no potatoes. Again, this is an example of the types of situations that occur with the current field feeding system.

The MRE presently is not packaged with a flameless ration heater. In Korea, MREs came forward of the line of troops, and the flameless ration heater did not accompany them. This made a significant difference in whether or not the soldiers ate the ration, especially in cold weather in November.

## PROPOSED ARMY FIELD FEEDING PROGRAM

Figure 4-2 contains the same basic schematic of Army Field Feeding System but has added new components to illustrate the proposed changes (see figure legend). First of all, cooks are being added back to the Army inventory. This is a major accomplishment because the rest of the Army is decreasing in size, and the program will be adding 300-plus cooks.

For the typical mechanized infantry battalion that has to feed 600 to 700 soldiers, this proposed program provides 3 additional cooks, resulting in a battalion with a total of 20 cooks. The big difference is how the 20 cooks will be used. When the program begins small mess teams will be placed forward, so each company in Figure 4-2 will have a mess team of two cooks. One of them will be a cook, and one will be an experienced soldier in the food

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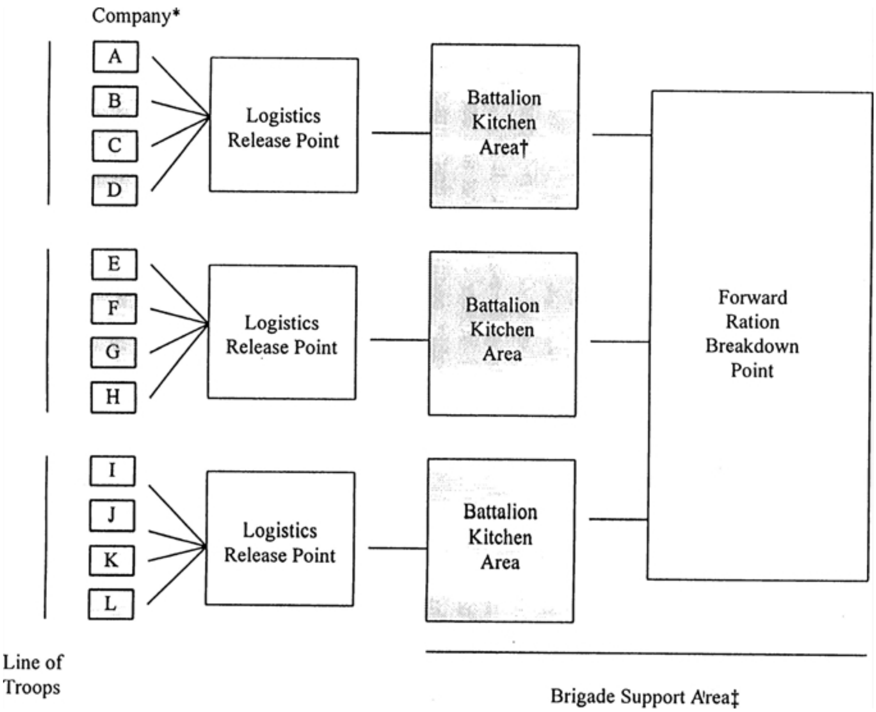


**FIGURE 4-2**
Schematic diagram of a mechanized infantry brigade illustrating the Army Field Feeding System-Future (AFFS-F).
* each company has one sanitation center, one Kitchen Company Level Field Feeding-Enhanced (KCLFF-E), and two cooks. †, each battalion kitchen area has one sanitation center and 12 cooks, ‡, the brigade support area (BSA) has one brigade foodservice warrant officer (food tech).

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business in the grade of E-5 with 5 or 6 years of experience. Therefore, in a mechanized infantry battalion there will be one mess team with cooks to support each of the rifle companies and anti-armor company. The remaining cooks will be positioned at the battalion field kitchen area, where the majority of food preparation will continue to be done.

Some kitchen equipment will also be needed. Before the number of cooks in the Army was drastically reduced, the former feeding system included many cooks, a kitchen tent, and a 2.5-ton truck, with generous kitchen supplies and equipment. The proposed system will accomplish similar preparations but with limited people, limited equipment, and some ration changes. In terms of equipment, the present kitchen level equipment will be enhanced with a field range (model M-59), and the Kitchen Company Level Field Feeding-Enhanced (KCLFF-E) equipment that provides limited cooking capability and moves forward with the company messes. Each company will also have a lighter truck called a high mobility vehicle (HMV) with a trailer to haul equipment on the battlefield.

Another improvement in equipment is the replacement of the immersion heaters that have been used for 50 years for sanitation equipment with a new sanitation center (SC). The SC was actually developed a number of years ago but was never purchased by the Army. The SC is needed when B Rations and some of A Rations are prepared to wash the pots and pans. It is a three-compartment sink with the same gas-operated burner units that are used for cooking purposes. This results in interchangeable equipment that require no modification in the present line, which is a quick, significant improvement. Therefore, with each mobile kitchen trailer (MKT) there will also be a sanitation center.

What does this do to solve the difficulties with the present Army field feeding program? The most significant item is the introduction of the KCLFF-E. The current KCLFF equipment is used in the battalion field kitchen area as nothing more than a heater cabinet to heat the Tray Ration or pan of food, and a pot cradle assembly to heat some water for soup or coffee.

The KCLFF-E has the M-59 field range that has been in Army inventory for a long time. This gives the company mess team the capability to roast, boil, bake, grill, and keep food truly hot in a serving line. The M-59 can also be configured to work like a steam-table adapter that will hold the inserts of food that arrive in an insulated food container. In the present system, the foods are prepared at the battalion kitchen, packed into insulated containers, and then served out of the containers to the soldiers. With the new system instead of serving it out of the insulated container to the soldiers, the food inserts can be removed and placed into the M-59 steam-table adapter to keep the food hot while the soldiers are coming through the line. The food will no longer be served lukewarm or cold. The M-59 also has an adaptor for the T Ration that permits the food tray to be placed directly on the unit to keep it hot. There are also three burners. In addition a 200-lb ice chest is part of the KCLFF-E. This

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will keep some of the perishable foods intact forward of the line of troops. Again, all of this equipment fits into the back of an HMV and the rations, personal baggage, and the like can be hauled in the attached trailer. These are very significant capabilities at the forward company level.

In terms of solving the difficulties described earlier, the KCLFF-E with the two cooks will follow the commander on the battlefield, warming beverages and food around the clock. This provides the commander with much more flexibility. For example, if scouts are on a mission and cannot eat with the rest of the group, when they return they can receive a warming beverage or something hot to go along with their MRE or other ration.

Having the cooks forward will solve many of the other logistical problems. They will ensure that the correct meal components are served together. They will ascertain that the flameless ration heaters have arrived with the MREs. Food will be served with attention to sanitation and basic presentation. The presence of forward cooks will help control many of the logistical issues that presently make meals unappetizing.

There also are some key changes proposed in the BSA. Previously there were warrant officers assigned to the BSA who served as the brigade commander's expert in field feeding. These positions were eliminated, taking that expertise away from the brigade commander. As time went on, the soldiers became more and more unhappy with what they were eating. Part of the reason was that there was no longer anyone in the BSA who was responsible for oversight of the field feeding logistics. With the new field feeding concept, there again will be a brigade foodservice warrant officer (food tech) in the BSA providing expertise to the brigade commander on food-related issues. Sixty-six personnel slots have been dedicated to food techs, which is significant. The food tech will develop the feeding plan for brigade- and battalion-size exercises. This is a key point because it is important to have someone who understands and pays attention to the appropriateness of specific rations for a military scenario.

A feeding plan has to be developed for the commander that includes the rations that appropriately match the tactical scenario. As an example of this, the Second Infantry Division in Korea just finished a major exercise, *Team Spirit*. This is an annual corps-level exercise that includes a number of divisions with many soldiers.

In an exercise of this nature, there are three major phases: the deployment phase, the maneuver phase, and the redeployment phase. During the deployment phase, the unit moves from their garrison area out to the field. The soldiers are not involved in any maneuver activity during this phase. A and B Rations can be used during this deployment phase on station or at the field site. Once the soldiers have arrived on site, they are in a staging phase as they are waiting to go forward. During the next phase, the maneuver phase, when there is high-intensity activity such as a fire mission, A and B rations are not appropriate because there is no time for food preparations. However, all of the

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menus in a specific ration can be put together for the commander. For example, if a maneuver cycle has T Rations and MREs, the food tech can make sure that the commander has all 10 T Ration menus and all of the MRE menu selections. These are the types of activities that can solve basic food delivery and menu diversity problems by reintroducing the brigade foodservice warrant officer back into the BSA. If factors such as these do not receive sufficient attention, soldiers end up eating lasagna day after day. This is one of the roles of the food tech. This soldier will ensure that repeated menu delivery problems of this nature do not happen. The food tech will work with the people who handle the rations to ensure the brigade receives all of the menus.

During the 30-d *Team Spirit* exercise in Korea, the unit had 10 of 10 T Ration menus and all of the B Ration menus. What a difference this made in morale! As long as the soldier sees variety and is not eating the same thing everyday, the complaints that have been heard previously about the T Rations and MREs are absent. However, it is the food tech that makes this possible.

The issue about training is also important. Training of soldiers, commanders, and all of those individuals at the leadership level ensures that there is an understanding that change has occurred. What the Army does not need is the senior leadership denigrating a specific ration. When that occurs then the young soldier soon starts complaining as well.

If there is a positive commander out in the field, soldiers are positive. If there is a negative platoon sergeant, then the platoon soldiers are negative. So the training aspect of the field feeding policy is critical, and the presence of a brigade foodservice warrant officer also helps with this important aspect of training the troops. The food tech also guarantees that the soldiers are trained in the use of the equipment. During peacetime, the food tech is assigned to the garrison mission.

### Long-Term Equipment Plans

Ideally the goal is to replace the mobile kitchen trailer (MKT) at some point. The MKT solves the present goals of developing a kitchen that is self-contained, using a typical container in Army inventory. The intent is to have electrical- or gas-based equipment that does not need a lot of time to preheat. The Army needs equipment that works merely by turning on a switch. This is achieved by mounting an electrical generator to run the equipment. It also has refrigeration capability and some water storage capability, and therefore contains all of the types of items needed for field feeding.

The intent for the future, therefore, is to develop a containerized kitchen that can do all of these types of food-related steps and more. However, this is

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not an urgent need. The MKT as presently described will continue to serve the Army well until something better is developed.

## PLANNING THE RATIONS

An issue of importance is water storage. The authorization for water trailers for the soldiers is at company level. Each company has water trailer on their authorization document. A water trailer holds enough water for the company's soldiers. Also at the BSA there are two water trailers that fulfill the cooking requirements for the battalion soldiers.

The proposed ration change is to move from the use of MREs and A, B, and T Rations to what is called a unitized group ration (UGR). It comes in six boxes and contains enough food to feed up to 100 soldiers. There are three different configurations of the UGR. The first one is a heat-and-serve option. This can be used if the commander does not have a lot of time but wants to serve cook-prepared or hot food to the soldiers. The heat-and-serve option is a tray pack item. It is heated in water, the can is opened, and it is fed to the soldiers. The point is that everything for that meal is in these boxes with the exception of milk and bread, which make the meal nutritionally adequate. These items are issued separately. Similarly, salad material for the lunch meals, fresh fruit, and other perishable items are provided separately.

The second option in the UGR is the B Ration option. These foods do not need refrigeration, but cooks are necessary food preparation. Again, all of the foods that are needed to prepare the ration are in the six boxes.

The third option is the A Ration option. Even with this fresh food meal, everything is contained the six boxes. It may be the same chicken meal, but now one has fresh chicken instead of the heat-and-serve chicken, or the B Ration's canned chicken.

Quick-to-prepare type foods are under development. When time is critical the Army needs food that is easy and quick, yet is a quality product. Chili and spaghetti are good examples. The Army cook does not need to make spaghetti sauce from scratch. There are good institutionalized spaghetti sauces that are commercially available. This is the type of item that will be developed for the UGR. Another example is gravy mix. If a cook makes gravy from scratch by the Army recipe, it takes 55 minutes. That is a lot of time, and the Army does not have the personnel to do that anymore.

Much of this food-item development is done in collaboration with the U.S. Army Natick Research, Development and Engineering Center and U.S. Army Research Institute of Environmental Medicine. Another example is the chicken breast in the T Ration. It is an excellent product, but the problem is that the soldier eats the same chicken breast with the same gravy everytime. If a heat-and-serve chicken breast can be placed in a can without a sauce, there could be a selection of sauces provided that change the taste of the meal. These are

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the types of changes in the ration concept that are under development with the UGR.

## CONCLUSION

Anything the Army can do to lead to a cook-prepared quality product is the goal. If there was a score card comparing the two ways feeding the soldier is done, one column would be headed "today," and the second column would be headed "beginning in 1996." The major differences that will have a significant improvement on soldier food intake are putting cooks forward to prepare meals for soldiers, giving the commanders the capability to provide their soldiers with different rations, providing cook-prepared meals, and moving newly configured equipment forward. Another key difference is the reintroduction of the brigade foodservice warrant officer into the BSA to ensure that the brigade commander has all the available assets. In summary, the U.S. Army Quartermaster Center and School conducted four *Army Field Feeding System-Future* field trials with units from the 18th Airborne Corps and the 29th Armored Division. The field trials validated that the AFFS-F concept meets tactical operational requirements and provides the capability to distribute, prepare, and serve one cook-prepared A or B Ration meal daily in the field, based on Mission, Enemy, Terrain, Troops, and Time (METT-T) available.

An executive summary brief of the field trial results and implementation plan was prepared, and the Department of the Army staff was briefed. Action officers are now working out the specifics concerning timelines for proper implementation of AFFS-F to the force structure. When their actions are completed, the field will be officially notified.

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# 5

# Commanders' Perceptions and Attitudes About Their Responsibility for Feeding Soldiers

*Celia F. Adolphi*[1]

## INTRODUCTION

Since the mid-1980s, the U.S. Army has been the torch bearer in health promotion for the Department of Defense with its Fit to Win Program (U.S. Department of the Army, 1987). Commanders at all levels have responsibility for executing this program. Because there has never been a survey of commanders' utilization of the health promotion program, a survey was conducted to obtain information from former commanders on their perceptions and attitudes about feeding soldiers. This information was compiled as a part of the author's military studies project, while a resident student at the Army War College in Carlisle, Pennsylvania from August 1991 to May 1992. Two additional goals of the survey were to determine what nutrition resources were being utilized as a part of health promotion and to estimate commanders' knowledge of nutrition.

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## SURVEY METHODS

Of the 288 members of the 1992 Army War College class, 132 Army officers had been in battalion level command sometime during the period from January 1990 to July 1991. These commanders were asked to take the survey. The survey group, which included three female officers, represented 63 percent of the active Army officers in the class. Because students were being asked to complete several other surveys, the scope of this survey was purposely limited.

To encourage maximum participation and minimize the time required to complete the survey, only 32 questions were constructed. The 32 questions were divided into 3 parts. In the first part of the survey, commanders were asked questions about their decisions on water discipline and ration selection during field training. They were asked whether they recommended electrolyte replacement beverages and protein supplements. Ten nutrition knowledge questions were included in the survey. These questions were taken from the U.S. Army Research Institute of Environmental Medicine's (USARIEM) August 1988 survey of Army basic trainees at Fort Jackson, South Carolina (Rose et al., 1989). Commanders were also asked to rank order their sources of nutrition education. Finally, the officers were offered the opportunity to make written comments following the survey. A Likert-type scale, with statements to which respondents indicated their agreement on a 5-point continuum, was used for response to 12 of the 32 questions. True or false (or undecided) were the response choices for the personal nutrition knowledge questions. The survey questions were analyzed using the statistical software program SPSS/PC+. A copy of the survey is included at the end of this chapter.

## RESULTS

Eighty-six percent (113) of the 132 commanders completed the survey. Fifty percent of respondents had commanded combat arms units; 25 percent commanded combat support units, and 25 percent commanded combat service support units. Thirty percent of the respondents had been deployed to Operation Desert Shield/Storm.

### Nutrition Knowledge

In response to the nutrition knowledge questions, only 43 percent of respondents could correctly identify that fat has twice as many calories as carbohydrates. Seventy-nine percent did not know that carbohydrate loading

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is only beneficial for events of 1 hour or less. Sixty-five percent did not know that one Meal, Ready-to-Eat (MRE) provides one-third of a day's calorie requirements. Ninety percent knew that breakfast is essential for enhanced physical and mental alertness. Fifty-five percent also knew that ingredients on food labels are arranged in order of decreasing quantity. When USARIEM asked basic trainees at Fort Jackson the same questions, 64 percent answered every question correctly, while only 7 percent of the former commanders correctly identified all nutrition questions (Rose et al., 1989). The wide variation in results between basic trainees' and officers' nutrition knowledge could result from increasing emphasis on nutrition education as early as elementary school.

Not surprising was the response from commanders that they had gained their nutrition knowledge from popular mass media sources rather than from nutrition professionals. As shown in Figure 5-1, commanders most often cited popular magazines as the source of their personal nutrition information, followed by popular books, their family members, and television. Doctors and dietitians were among the least frequently cited sources of nutrition information.

Sixty percent of the officers agreed that the Army places too little emphasis on nutrition as a component of overall health and fitness. Half of the

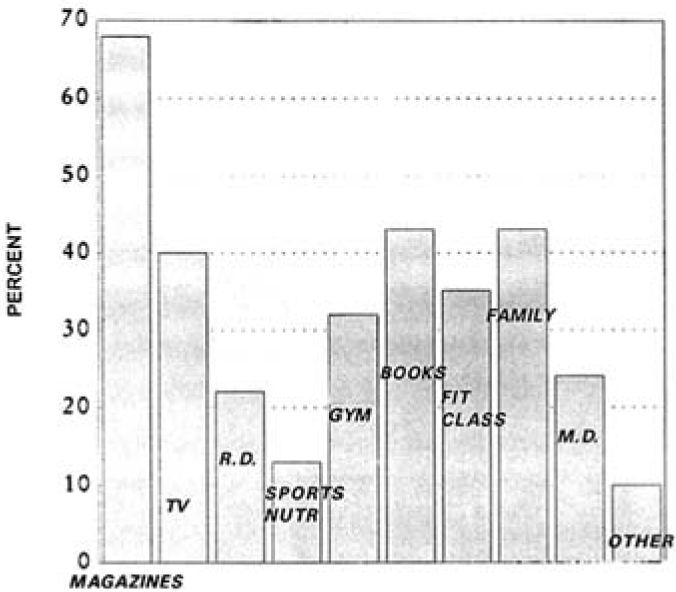


**FIGURE 5-1**
Factors influencing personal knowledge of nutrition.
Factors are shown as percentages.
Commanders could indicate as many choices as applied.

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respondents also indicated that the relationship of fitness and nutrition is not well understood. Eighty-eight percent indicated that Army personnel associate nutrition only with weight control. This finding is important to remember when exploring the reasons for underconsumption of rations.

## Commanders' Perceived Responsibility for Feeding Soldiers

What soldiers eat is often determined by the training priorities of commanders. Since it is known that over time, nutritional fitness can affect combat readiness, the survey included questions about the commanders' perceived relationship of healthful eating and combat performance. Only 51 percent indicated that there was any relationship. Sixty-three percent of the former commanders surveyed by this questionnaire responded that they were involved in the decision process to determine the type of rations used during field training. Their answers are summarized in Figure 5-2. When asked to rank order the reasons that framed their decisions, the training scenario was rated as the most important reason (38 percent), followed by time to prepare rations (23 percent), soldier preference (16 percent), dislike for operational

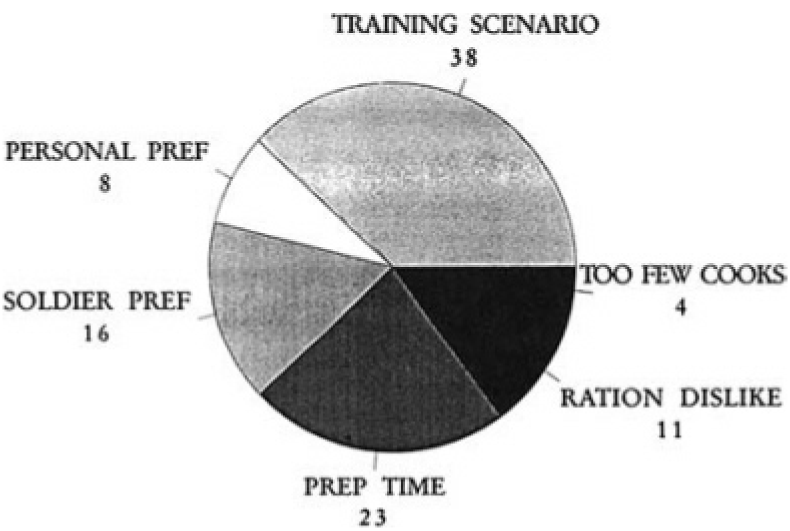


**FIGURE 5-2**
Factors which influence ration choice during field operations.
Factors were rank ordered by commanders. Factors are shown as percentaged rankings.

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rations (11 percent), and personal preferences (8 percent). Of those commanders, the answers from those who had been deployed to Operation Desert Shield/Storm were subsequently analyzed separately. Their answers did not differ from the other commanders. When asked whether "pogey bait," a common troop term for nonnutritionally dense snack foods, provided acceptable substitutes for military rations, 87 percent indicated that pogey bait is not an acceptable substitute.

Several commanders indicated that they knew their soldiers purposely planned to lose weight during field training. Little, if any, command emphasis is placed on eating to maintain performance. Commanders are no longer required to have all their soldiers line up for meals, a method intended to ensure that soldiers were eating.

## Anecdotal Comments

There was a section of the survey that encouraged comments. One former commander wrote that his battalion was in excellent shape before and during Operation Desert Shield/Storm because of the emphasis on nutrition and physical training. He felt that more emphasis on nutrition would have been beneficial. Another former commander stated that soldiers are fast-food factories and self-perceived as immortal—a true product of American society. He felt that there needs to be a focus on changing the young soldier's understanding of nutrition. A former reception battalion commander said that young soldiers have an aversion to anything green or anything that looks or tastes unusual. This officer felt that eating habits are a reflection of society and home and that soldier eating habits will not improve until those of the general society improve. He suggested that the Army incorporate more nutrition training as a part of basic and unit training.

A commander deployed to Operation Desert Shield/Storm indicated his battalion ate MREs for 52 days straight, with only two minor cases of constipation because of command emphasis on water and fresh fruit consumption. This commander felt that feeding was the biggest morale factor that could be controlled. In contrast, another commander stated that MREs are a disaster and that pogey bait is the only thing to get troops through when MREs are the only ration available. Adding ingredient and nutrition information to the MRE package was suggested by several commanders.

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## DISCUSSION

This small sample cannot be construed as representative of all commanders' perceptions and attitudes about feeding soldiers, but it does indicate that much can be done to increase commanders' (and soldiers') nutrition knowledge. Over half of those surveyed had not used the Army's Fit to Win Program (U.S. Department of the Army, 1987), including the nutrition education component, in the ways envisioned by proponents of the program. The survey also revealed that commanders' information on nutrition is more likely to come from popular magazines than from nutrition professionals. In order to set a positive leadership climate, change unfounded perceptions about eating, and make an impact on solders' attitudes about eating, officers need more focused information on the rationale for healthful eating under various military conditions as well as an orientation to reliable nutrition sources. Such fitness and nutrition education needs to begin early in an officer's career.

## RECOMMENDATIONS

Deciding that eating is important to the maintenance of combat performance is a state of mind. This survey of former commanders underscores the need for a hierarchical educational program to provide a basic understanding of the relationship between nutrition and combat performance. Such a hierarchical program would begin at the lowest military education level. At each succeeding level of military education, more complex fitness and nutrition concepts are added. Hierarchical programs should be provided for both officers and enlisted personnel. As officers reach command levels, they should be given a list of appropriate resources for nutrition education and healthful eating information, such as dietitians and master fitness trainers. The following recommendations address this need:

- Survey commanders and soldiers returning from any operation other than war about ration consumption and weight loss.
- Include progressively more complex health promotion instruction, including nutrition education, in all U.S. Army Training and Doctrine Command programs of instruction, including precommand courses.
- Train physician's assistants to teach soldiers the fundamentals of nutrition and performance, since they are often the first, and only, medical personnel to interface with soldiers.
- Provide USARIEM's publication, *Nutritional Guidance for Military Field Operations in Temperature and Extreme Environments* (Thomas et al., 1993), to all precommand course participants.

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- Army Regulation 350-15 charges the Commandant of the Army War College with responsibility for conducting fitness education and training programs for Army War College personnel and for conducting applied fitness research. This responsibility is performed by the Army Physical Fitness Research Institute (APFRI). Therefore, it is recommended that APFRI annually survey Army War College and Command and General Staff College classes to measure the understanding of the fundamental concepts of nutrition and performance, ration consumption patterns, and influences on soldiers' eating habits.

Although 51 percent of the commanders who were surveyed indicated a positive relationship between nutrition and combat performance, the study also shows that the nutrition education component of the Army's Fit to Win Program is not supporting this fundamental principle. Unfortunately, achieving an understanding of the role of nutrition in combat efficiency has not progressed very far since R. M. Kark's (1954) comment: "… loss of military efficiency through inadequate nutrition is most often due to inadequate planning, catering or supply, and to inadequate training or indoctrination… Maintaining good nutrition is like maintaining freedom of speech or democracy. You need eternal vigilance to make it work" (p. 194). Implementing the recommendations is part of the eternal vigilance of which Kark speaks. Indiscriminate nutrition information will not ensure that commanders properly understand how to fulfill their obligation in feeding soldiers, under any and all military environments.

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## DISCUSSION

RICHARD JANSEN: It seems like in the reports from 1977, increasingly the whole thrust of nutrition education has been to reduce the risk of chronic disease, and it has not been related to these problems of the Army at all, which are more important from a functional standpoint or from a performance standpoint. We cannot worry so much about your percentage of calories from fat if they are not getting enough food to maintain body weight. Or for that matter, I think for us today even within the labeling regulations, we do not worry about vitamins and minerals at all. We just assume they are there, we are just going to worry about fat. I am wondering what, within the curriculum today at West Point or in ROTC or at OCS, the officer trainees are being taught about the importance, not of reducing chronic disease, but of making sure that soldiers eat adequately for performance.

CELIA ADOLPHI: I can tell you we are not doing enough. We are kind of skimming the surface, and what we are teaching is that moderation and variety are important to achieving balance, but we do not focus on the aspect of eating for performance.

EILEEN THOMPSON: But I think that has been a more difficult thing to demonstrate.

CELIA ADOLPHI: There is one ray of hope in that the American Dietetic Association 1993 Survey of American Attitudes toward nutrition has just come out. They found that the biggest increase in interest and concern about nutrition was in young men. So they are getting there.

ROBERT SMITH: A question on your survey. Was the military concerned about being obese, overweight?

CELIA ADOLPHI: Well, let me say this. Everybody tries to stay off the weight control program. It is kind of a stigma really. Once you are on the weight control program, you cannot get promoted, you cannot go to school, your record is flagged. It is a punitive program, frankly, so that is why I think that nutrition gets wrapped into that aspect of weight control.

GILBERT LEVEILLE: I would like to get to Dick's point. If you have the same kind of dichotomy in the military that you do elsewhere, you are talking about underconsumption during field operations and not during regular garrison feeding where you have a problem of overconsumption there more than anywhere else.

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CELIA ADOLPHI: I would like to share with you, though, that one of the problems we have now is underconsumption of field rations. As our Army gets smaller, they are going to go to the field more often. I can tell you after having been to Fort Stewart, Georgia last Friday, and having talked to other commanders, they hardly come home, have a chance for a shower, and a chance to kiss their wife and kids until they are off again. The frequency of rotations at the National Training Center is increasing. They want to keep that tempo, that readiness alive, to make sure we do not have what we call the "hollow Army" again as we did after Korea. So there is a lot of stress being placed on commanders to keep the training, keep going to the field. So I am somewhat concerned that this issue, if we have one, increases.

ROBERT NESHEIM: It is complicated by virtue of an education program that now has the dual objectives of maintaining adequate consumption in the field but preventing overconsumption in the garrison.

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## NUTRITION IN COMMAND SURVEY

### PART I COMMANDER'S ROLE IN NUTRITIONAL FITNESS

CIRCLE YOUR RESPONSES.

AS A COMMANDER:

1. How often did you use the Army Health Promotion FIT TO WIN (DA PAM 600-63) materials for commanders?

FREQUENTLY OCCASIONALLY RARELY NEVER

2. Did you include nutrition education as part of your unit's FIT TO WIN program?

YES NO
(If Yes, Who Administered ____________________________)

3. Did you ever recommend soldiers consume a commercial electrolyte drink (ex. Gatorade-like drink) rather than water?

YES NO
(If Yes, In What Situation(s)____________________________)

4. Did you ever recommend soldiers consume protein supplements?

YES NO
(If Yes, Under What Conditions ____________________________)

5. What impact did the Army Field Feeding System have on your unit's ability to perform the mission?

VERY POSITIVE | SOMEWHAT POSITIVE | SOMEWHAT NEGATIVE | VERY NEGATIVE | NO EFFECT

6. Did you, as the commander, decide the type of rations to be used during field operations?

YES NO
(If Yes, rank order the reasons which contributed to your decision. Rank from 1 to 6 with 1 the most important reason.)

________ Training scenario
________ Personal preferences
________ Soldier preferences
________ Time for food preparation
________ Dislike for operational rations
________ Too few cooks

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TO THE RIGHT OF THE STATEMENTS BELOW, CIRCLE THE LETTER WHICH BEST INDICATES YOUR RESPONSE:

SA Strongly Agree
A Agree
U Uncertain or Neither Agree or Disagree
D Disagree
SD Strongly Disagree

7. Army personnel understand the relationship between healthful eating and optimum combat performance. SA A U D SD

8. "Pogey-bait" snacks are acceptable substitutes for government provided meals. SA A U D SD

9. Nutrition labels on Meal, Ready to Eat (MRE) packages would aid in making food choices. SA A U D SD

10. One MRE provides one-third of the daily caloric requirements for a moderately active soldier. SA A U D SD

11. The linkage between a well-balanced diet and fitness is well understood by Army personnel. SA A U D SD

12. Command emphasis is required to get soldiers to consistently drink water to maintain hydration. SA A U D SD

TO THE RIGHT OF THE STATEMENTS BELOW, CIRCLE THE LETTER WHICH BEST INDICATES YOUR RESPONSE:

SA Strongly Agree
A Agree
U Uncertain or Neither Agree or Disagree
D Disagree
SD Strongly Disagree

13. Master Fitness trainers were effectively utilized in my command organization. SA A U D SD

14. Master fitness trainers could be counted on to provide reliable nutrition information. SA A U D SD

15. An Army dietitian was available to provide nutrition education to my soldiers. SA A U D SD

16. Army officers are very influential in a soldier's food choices. SA A U D SD

17. The Army places too little emphasis on nutrition as a component of overall health and performance. SA A U D SD

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18. Army personnel associate eating habits and nutrition MOSTLY with the Army weight control program. SA A U D SD

PART II NUTRITION KNOWLEDGE

TO THE RIGHT OF THE STATEMENTS BELOW, CIRCLE YOUR RESPONSE:

19. Fat has more than twice as many calories as carbohydrates. True False Undecided

20. The ingredients listed on food labels are arranged in order of decreasing quantity. True False Undecided

21. Low fat milk has fewer calories and less cholesterol than whole milk. True False Undecided

22. Water is essential for the body to function properly. True False Undecided

23. Increasing the consumption of vegetables, fruits, and whole-grain breads and cereals will aid digestion and elimination. True False Undecided

24. To aid physical and mental alertness, one-third of the day's calories should be consumed for breakfast. True False Undecided

25. Carbohydrate loading will enhance performance in all events of one hour or less. True False Undecided

26. The best weight loss method is to consume fewer calories in a well-balanced diet and to increase exercise. True False Undecided

27. The APFRI health and fitness assessment has increased my understanding of nutrition in relation to total well-being. True False Undecided

28. I obtain the most of my nutrition information from: (Check all that apply)

_____ Popular magazines/newspapers
_____ Radio/television
_____ Dietitian
_____ Sports Nutritionist
_____ Gym/Fitness Facility
_____ Nutrition Books
_____ Fitness Class
_____ Family Member
_____ Physician/Nurse
_____ Other (Specify)

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**PART III GENERAL INFORMATION**

29. Which of the following best describes the type of unit you last commanded?

______ Combat Arms
______ Combat Support
______ Combat Service Support
______ Other (please identify ______________)

30. Were you deployed to Operation Desert Shield/Storm as a battalion (or equivalent) commander?

YES NO

32. COMMENTS.

THANK YOU FOR YOUR PARTICIPATION.
RETURN TO CELIA ADOLPHI, BOX 39 BY 19 DECEMBER 1991.

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# 6

# Nutritional Criteria for Development and Testing of Military Field Rations: An Historical Perspective

*David D. Schnakenberg*[1]

## INTRODUCTION

Nutritional standards for the development and procurement of military rations and Military Recommended Dietary Allowances (MRDAs) (AR 40-25, 1985) for feeding military personnel and assessing the nutritional adequacy of their nutrient intakes have evolved over the past 80 years. These standards and dietary recommendations have been described in various military publications and, beginning during World War II, were prescribed in military regulations. However, specific nutritional criteria for field testing of military rations have emerged from the Office of the Surgeon General (OTSG) of the Army only during the past 10 to 12 years. These criteria were applied during an extensive series of field ration trials that were conducted by the U.S. Army Research Institute of Environmental Medicine (USARIEM) and U.S. Army Natick Research, Development and Engineering Command (USANRDEC) during the same period. The Committee on Military Nutrition Research (CMNR)

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participated, in an important advisory capacity to the OTSG, in the recent revisions of the MRDAs and nutritional standards. The CMNR also provided advisory input into the development of the nutritional criteria as well as into the assessment and interpretation of the nutritional data from several of these important field ration trials. Nutritional and other biomedical data were specifically requested and subsequently used by general officers on the Army staff to make decisions during 1986–1988 that improved not only nutritional quality and food consumption, but also troop acceptability of the Meal, Ready-to-Eat (MRE) and Tray rations (T Rations) that were successfully used in military operations during Operation Desert Storm and in Somalia in the early 1990s.

This chapter will briefly review the history of the development of nutritional standards and MRDAs and then, drawing largely on personal experiences while this author was assigned to OTSG and USARIEM, describe the development and application of the nutritional criteria that were used during field testing of military rations during the 1980s and the involvement of the CMNR in those activities.

## NUTRITIONAL STANDARDS FOR DEVELOPMENT OF MILITARY RATIONS

L. R. Holbrook, Director of the Training School for Bakers and Cooks, Fort Riley, Kansas, provided the following nutritional guidance in the 1916 edition of *The Mess Sergeant's Handbook* (Holbrook, 1916, p. 31):

> Nothing is of greater importance than that a well-balanced diet be prepared—that is, that a suitable *variety* of foods appear on the bills of fare, and the various components be served in *appropriate quantities*.

Few nutritionists or dietitians today would take strong exception to Holbrook's general guidance for feeding soldiers. The nutrition experts developing the next edition of the Department of Health and Human Services-U.S. Department of Agriculture's *Dietary Guidelines for Americans* may wish to consider adopting John Murlin and Casper Miller's nutritional recommendations for training of soldiers (1919). They recommended a proposed training ration that contained 12.6 percent calories from protein, 30.3 percent calories from fat, and 57.1 percent calories from carbohydrate. The Nutrition Advisory Council to the Army Surgeon General recommended in that same article that the nutrient requirements for training of soldiers was 12.5 percent calories from protein, 25 percent calories from fat, and 62.5 percent calories from carbohydrate.

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During World War II, the Army Surgeon General was given specific responsibilities for nutrition (U.S. Department of the Army, 1945; U.S. War Department, 1944), including to:

- determine the nutritional state of military personnel,
- prescribe basic standards of diet for the Army under various conditions of operations,
- report nutritional deficiencies and recommend corrective measures,
- determine nutritional adequacy of menus and rations consumed to ascertain conformance to prescribed nutritional standards, and
- advise and cooperate with the Quartermaster Corps to secure and maintain nutritional adequacy of the ration.

As noted in an historical account of ration development during World War II (Samuels et al., 1947), a nutritional standard is needed to plan any ration. The standard should be based on requirements adequate for optimal nutrition and not on minimal requirements. Furthermore, nutritional standards should be based on the combined judgments of nutrition authorities and not developed by individual effort. To help establish a satisfactory standard, the Food and Nutrition Board (FNB) of the National Research Council (NRC) was organized in 1940 in conjunction with the defense program. During World War II, the Army Surgeon General's office usually accepted diets as nutritionally adequate if they met the recommended dietary allowances of the FNB published in January 1943 and June 1945 (NRC, 1941, 1945).

After World War II, the term *minimum nutrient intake* was used for the basic dietary standards for garrison and field rations in the 1947 version of Army Regulation 40-250 (U.S. Department of the Army, 1947). The calorie standard of 3,600 kcal/d in temperate climates was raised to 4,400 kcal/d for extreme cold environments. This regulation was revised again in 1949 (U.S. Department of the Army, 1949) to include standards for female personnel with adjustments for active and sedentary males. The first regulation on nutrition standards representing three branches of the military (Tri-Service Regulation) appeared in 1968 (U.S. Departments of the Army, the Navy, and the Air Force, 1968). Dietary allowances were adopted as nutritional standards based on the 1964 edition of the FNB's Recommended Dietary Allowances (RDAs) (NRC, 1964) with adaptation as required. It was recommended that the desirable proportion of total calorie intake from fat sources was 40 percent or less, and that menus should provide no more than 45 percent of calories from fat sources. The calcium allowance was raised to 1,400 mg for males and 1,300 mg for females. The regulation was revised again in 1969 (U.S. Departments of the Army, the Navy, and the Air Force, 1969) based on the 1968 edition of the RDAs (NRC, 1968). The calcium allowance was lowered to 800 mg, and to reduce risk of heart disease, a reduction of total fat content of the menus to 42 percent of calories, with some substitution of polyunsaturated for saturated

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fats, was recommended. The regulation was revised again in 1970 (U.S. Departments of the Army, the Navy, and the Air Force, 1970) with added emphasis that fat should not exceed 40 percent of calories in planned menus. T. D. Boaz (1970) from the OTSG explained that the reason for the higher protein allowance for the military is to enable menu planners to provide a diet that is highly acceptable, to incorporate other nutrients with ease, and to provide for the growth needs often found in younger recruits. The regulation was subsequently revised in 1971 and 1972 with no major changes. The 1976 revision (U.S. Departments of the Army, the Navy, and the Air Force, 1976) was based on the 1974 edition of the RDAs (NRC, 1974).

In 1985 the regulation was revised again (U.S. Departments of the Army, the Navy, and the Air Force, 1985) with significant advisory input from the CMNR. The MRDAs were adapted from the 1980 edition of the RDAs (NRC, 1980), and the values for males and females are provided in Table 6-1. A summary of the changes in recommended nutrient allowances from 1943 to 1985 is shown in Table 6-2. The MRDAs were defined as the "daily essential nutrient intake levels" presently considered to meet the known nutritional needs of practically all 17- to 50-year-old, moderately active military personnel." The MRDAs were intended for use by professional personnel involved in menu planning, dietary evaluation on a population basis, nutrition education, nutrition research, and food research development. The MRDAs were expanded to include safe and adequate adult dietary intake ranges for selected nutrients, known to be essential, but for which recommended levels of intake had not been established. The 1985 edition also explicitly prescribed nutrient standards for operational and restricted rations, and these values are shown in Table 6-3. The intent was for the nutrient standards to be used to evaluate the nutritional adequacy of the ration itself as formulated or as procured, whereas the MRDAs were to be used to evaluate the adequacy of the nutritional intakes of a group of soldiers consuming the ration over a period of several days.

The 1985 edition (AR 40-25, 1985) also recommended that dietary intakes from fat should not exceed 35 percent of total calories for garrison meals, but it allowed up to 40 percent of calories from fat for operational and restricted rations. For the first time, a goal for the sodium content in foods as served in military food service systems was established at 1,700 mg of sodium per 100 kcal. Energy allowances for extreme cold weather operation were adjusted to 4,500 kcal/d for men and 3,500 kcal/d for women.

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TABLE 6-1 MRDA for Selected Nutrients1

| Nutrient | Unit Kcal MJ | Male 3200(2800–3600) 13.4(11.7–15.1) | Female 2400(2000–2800 10.0(8.4–11.7) |
|---|---|---|---|
| Energy[2],[3] | | | |
| Protein[4] | gm | 100 | 80 |
| Vitamin A[5] | mcg RE | 1000 | 800 |
| Vitamin D[6],[7] | mcg | 5–10 | 5–10 |
| Vitamin E[8] | mg TE | 10 | 8 |
| Ascorbic Acid | mg | 60 | 60 |
| Thiamin ($B_1$) | mg | 1.6 | 1.2 |
| Riboflavin ($B_2$) | mg | 1.9 | 1.4 |
| Niacin[9] | mg NE | 21 | 16 |
| Vitamin $B_6$ | mg | 2.2 | 2.0 |
| Folacin | mcg | 400 | 400 |
| Vitamin $B_{12}$ | mcg | 3.0 | 3.0 |
| Calcium[7] | mg | 800–1200 | 800–1200 |
| Phosphorus[7] | mg | 800–1200 | 800–1200 |
| Magnesium[7] | mg | 350–400 | 300 |
| Iron[7] | mg | 10–18 | 18 |
| Zinc | mg | 15 | 15 |
| Iodine | mcg | 150 | 150 |
| Sodium | mg | See note[10] | See note[10] |

[1] MRDA for moderately active military personnel, ages 17 to 50 years, are based on the *Recommended Dietary Allowances*, ninth revised edition, 1980.
[2] Energy allowance ranges are estimated to reflect the requirements of 70 percent of the moderately active military population. One megajoule (MJ) equals 239 kcals.
[3] Dietary fat calories should not contribute more than 35 percent of total energy intake.
[4] Protein allowance is based on an estimated protein requirement of 0.8 gm/kilograms (kg) desirable body weight. Using the reference body weight ranges for males of 60 to 79 kilograms and for females of 46 to 63 kilograms, the protein requirement is approximately 48 to 64 grams for males and 37 to 51 grams for females. These amounts have been approximately doubled to reflect the usual protein consumption levels of Americans and to enhance diet acceptability.
[5] One microgram of retinol equivalent (mcg RE) equals 1 microgram of retinol, or 6 micrograms betacarotene, or 5 international units (IU).
[6] As cholecalciferol, 10 micrograms of cholecalciferol equals 400 IU of vitamin D.
[7] High values reflect greater vitamin D, calcium, phosphorus, magnesium, and iron requirements for 17- to 18-year olds than for older ages.
[8] One milligram of alpha-tocopherol equivalent (mg TE) equals 1 milligram d-alpha-tocopherol.
[9] One milligram of niacin equivalent (mg NE) equals 1 milligram niacin or 60 milligrams dietary tryptophan.
[10] The safe and adequate levels for daily sodium intake of 1100 to 3300 mg published in the RDA are currently impractical and unattainable within military food service systems. However, an average of 1700 milligrams of sodium per 100 kilocalories of food served is the target for military food service systems. This level equates to a daily sodium intake of approximately 5500 milligrams for males and 4100 milligrams for females.
SOURCE: AR 40-25 (1985). U.S. Department of the Army, the Navy and the Air Force.

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TABLE 6-2 Summary of Changes in Nutritional Standards for the Military (1943–1985)

| Reference Nutrition | Standards* | Energy † (kcal) | Protein (g) | Fat (% kcal) | Calcium (mg) | Iron (mg) | Vit. A (IU) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | Vit C (mg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FNB RDA‡ | 1943 | 3,000 | 70 | — | 800 | 12 | 5,000 | 1.8 | 2.7 | 18 | 75 |
| | 1945 | 3,000 | 70 | — | 800 | 12 | 5,000 | 1.5 | 2.0 | 15 | 75 |
| AR 40-250§ | 1947 | 3,600 | 100 | — | 700 | — | 5,000 | 1.6 | 2.2 | 16 | 50 |
| | 1949 | 3,600‖ | 100 | — | 700 | — | 5,000 | 1.6 | 2.2 | 16 | 50 |
| | | 3,000# | 100 | — | 700 | — | 5,000 | 1.6 | 2.2 | 16 | 50 |
| Tri-Service Regulation** | 1968 | 3,400 | 100 | <40%††‡‡ | 1,400 | 18 | 5,000 | 1.4 | 2.0 | 22 | 60 |
| | 1969 | 3,400 | 100 | <40%††‡‡ | 800 | 14 | 5,000 | 1.7 | 2.0 | 22 | 60 |
| | 1970 | 3,400 | 100 | <40%††‡‡ | 800 | 14 | 5,000 | 1.7 | 2.0 | 22 | 60 |
| | 1976 | 3,200 | 100 | <40% | 800 | 18 | 5,000 | 1.6 | 2.0 | 21 | 60 |
| | 1985 | 2,800–3,600 | 100 | <35% | 800–1,200 | 10–18 | 1,000 (µg RE) | 1.6 | 1.9 | 21 | 60 |
| | | Na (mg/1,000 kcal) | P (mg) | | Mg (mg) | | Zn (mg) | I (µg) | Vit. $B_6$ (mg) | Folacin (µg) | Vit. $B_{12}$ (µg) |
| | 1985 | 1,700 "goal" | 800–1,200 | | 350–400 | | 15 | 150 | 2.2 | 400 | 3.0 |

* Male personnel; † Assumes temperate climate; ‡ National Research Council (1941, 1945); § U.S. Department of the Army (1947, 1949); ‖ Physically active; # Performing sedentary duties; ** U.S. Departments of the Army, the Navy, and the Air Force (1968, 1969, 1970, 1976, 1985); †† < 40% intake; ‡‡ < 45% for menus (1968); < 42% for menus (1969); < 40% for menus (1970).77

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TABLE 6-3 Nutritional Standards for Operational and Restricted Rations

| Nutrient | Unit[1] | Operational rations | Restricted rations[2,4] |
|---|---|---|---|
| Energy | Kcal | 3600 | 1100–1500 |
| Protein | gm | 100 | 50–70 |
| Carbohydrate | gm | 440 | 100–200 |
| Fat | gm | 160(maximum) | 50–70 |
| Vitamin A | mcg RE | 1000 | 500 |
| Vitamin D | mcg | 10 | 5 |
| Vitamin E | mg TE | 10 | 5 |
| Ascorbic Acid | mg | 60 | 30 |
| Thiamin | mg | 1.8 | 1.0 |
| Riboflavin | mg | 2.2 | 1.2 |
| Niacin | mg NE | 24 | 13 |
| Vitamin $B_6$ | mg | 2.2 | 1.2 |
| Folacin | mcg | 400 | 200 |
| Vitamin $B_{12}$ | mcg | 3 | 1.5 |
| Calcium | mg | 800 | 400 |
| Phosphorus | mg | 800 | 400 |
| Magnesium | mg | 800 | 400 |
| Iron | mg | 18 | 9 |
| Zinc | mg | 15 | 7.5 |
| Sodium | mg | 5000–7000[5] | 2500–3500[5] |
| Potassium | mg | 1875–5625 | 950–2800 |

[1] See notes in Table 6-1 for explanation of units.
[2] Values are minimum standards at the time of consumption unless shown as a range or a maximum level.
[3] The operational ration includes the MCI, MRE, A, B, and T Rations.
[4] Restricted rations are for use under certain operational scenarios such as long-range patrol, assault, and reconnaissance when troops are required to subsist for short periods (up to 10 days) on an energy restricted ration.
[5] These values do not include salt packets.
SOURCE: AR 40-25 (1985). U.S. Department of the Army, the Navy and the Air Force.

## NUTRITIONAL CRITERIA FOR TESTING MILITARY RATIONS

The MRDAs for military personnel and the nutritional standards for operational and restricted rations were the primary references used to develop the nutritional criteria that were used during an extensive series of field ration feeding trials conducted during the 1980s. Examples will be provided from the following four major ration tests:

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- 1983 MRE Test—Hawaii;
- 1985 CFFS-FDTE Test—Hawaii;
- 1986 MRE Improvement Test—Hawaii; and
- 1989 MRE Cold-Weather Supplement Test—Alaska.

## Background on Development of the Meal, Ready-to-Eat Ration

The Meal, Combat Individual (MCI) or, more familiarly, the C Ration was a ration packaged in small tin cans and used extensively during the latter part of World War II and during the Korean and Vietnam wars. Beginning in the 1970s, the Army began developing a replacement for the MCI, packaged in a flexible pouch. This ration, which became known as the Meal, Ready-To-Eat (MRE), was not extensively field tested for nutritional adequacy during its development because the emphasis at the time was on changing the packaging, not the food. Difficulties in obtaining approval for the packaging from the U.S. Food and Drug Administration delayed the procurement and delivery of the new MRE until 1983, by which time the existing stocks of C Rations were almost exhausted.

The Office of the Deputy Chief of Staff for Logistics (ODCSLOG) of the Army had initially requested in 1977 that the OTSG conduct a field test to determine whether the new MRE could be used as sole source of subsistence for troops for periods up to 30 days. This question arose because the Headquarters Department of the Army (HQDA) policy at that time, based upon general guidance contained in existing technical manuals and bulletins (U.S. Department of the Army, 1961, 1971, 1974), stated that "the Meal Combat Individual (MCI) ration, although formulated to be nutritionally adequate, should not be used as sole source of food for periods in excess of 10 consecutive days." The rationale given was that the ration will become monotonous, troop acceptance and nutrient intakes will decrease, morale will deteriorate, and as a consequence, troop performance and health may be adversely affected. No one in the OTSG at that time apparently was willing to approve a change in policy for a ration that had not been adequately tested or even produced. Unfortunately, the senior leadership of the U.S. Army Medical Research and Development Command (USAMRDC) at that time was also unwilling to fund and conduct an extensive 30-d field ration trial because they were in the process of disestablishing their existing military nutrition research program at the Letterman Army Institute of Research (LAIR). The Army's nutrition research program at LAIR was eventually transferred, at the direction of Congress, to the U.S. Department of Agriculture in 1979.

## 1993 MRE Test—Hawaii

The ODCSLOG requested again in 1982 that a 30-d test of the soon-to-be-fielded MRE be conducted, and USANRDEC agreed to conduct the field trial

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Not Eating Enough: Overcoming Underconsumption of Military Operational Rations
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at the Pohakuloa Training Area on the Big Island of Hawaii. Hirsch (see Chapter 9 in this volume) reports the results from the 1983 MRE test. The Commander of USANRDEC asked Major General Garrison Rapmund, Commanding General of USAMRDC, to review and comment on the USANRDEC test plan. As General Rapmund's nutrition staff officer, this author referred the test plan to the CMNR and subsequently incorporated their initial reactions with his own in General Rapmund's response back to USANRDEC. It was agreed that food composition should be measured daily throughout the 6-wk trial and that average daily nutrient intakes should meet the MRDAs. It was also agreed to follow USANRDEC's proposals to measure food acceptance (by hedonic questionnaire), body composition (by anthropometry), hydration status (by urine osmolality), biochemical status (by serum ascorbic acid, serum retinal), and individual morale (by questionnaire) at 2-wk intervals and to measure body weight and screen clinical symptoms by checklist at weekly intervals. These data were to be used to test for differences in responses between a unit of at least 30 soldiers consuming three MREs per day (experimental group) for 6 consecutive weeks compared to a similar unit (control group) consuming two hot, cook-prepared A Ration meals and one MRE per day for 6 weeks. Ideally, there should have been an additional control group fed three MCIs per day so that there would also have been a direct side-by-side comparison of the new (MRE) and old (MCI) ration. However, there were insufficient quantities of the old MCI available for this test.

Although it had been decided that the latest (1976) version of the MRDAs should be used as nutritional criteria for the 1983 MRE test, it was not clear what interpretation should be made if average daily energy intakes fell below the energy MRDA of 3,200 kcal/d. It was agreed that data on body weight change should also be assessed, but there was no existing body weight change criterion established for use in field ration testing. As an interim criterion, this author suggested in General Rapmund's letter to USANRDEC that an average weight loss of less than 5 lb (2.3 kg) could be used to assess how long troops engaged in a 6-wk field exercise will consume sufficient quantities of the test rations to maintain body weight.

After the 1983 MRE test was completed and the initial data were analyzed, USANRDEC forwarded a copy of their preliminary data for review and comment by USAMRDC and the CMNR. The CMNR provided comments in their Letter Report and the following recommendations on what constitutes unacceptable body weight loss (NRC, 1985, p. 2):

> Average weight loss of 5 percent during combat or training exercises of approximately one month's duration would be acceptable for healthy fit troops, without significant adverse effects on health or performance. However, body weight loss of 10 percent or more for individuals should be cause for concern. Individual weight loss of 3 percent or more in a one day period due to dehydration would be unacceptable, and could result in excessive losses of physically able troops.

Hirsch (see Chapter 9 in this volume) reports that average daily energy intakes of individuals in a study who ate three MREs per day were far below

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the 3,200 kcal/d as listed in the MRDAs (AR 40-25, 1985), and intakes continued to decline as the test progressed despite an average body weight loss that exceeded 5 percent. The OTSG reviewed the data and concluded that there was no evidence from this trial to support revision of the existing 10-d restriction on the use of individual rations such as the MRE as the sole source of food.

## Background on Development of the Combat Field Feeding System-Force Development Test and Experimentation

The development and eventual fielding of the Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) resulted in major changes in what and how U.S. military troops are to be fed in combat and during operational training. In the early 1980s, there was a strong movement within the senior leadership of the Army to create a new Light Infantry Division, but Congress would not authorize an increase in the total size of the Army. Under these circumstances, the only option to increase the "tooth" of the Army was to reduce the size of the logistical "tail." One of the general officers in charge of creating the Light Infantry Division learned about a concept briefing being given in the Pentagon by the Quartermaster School that proposed a new feeding system that could greatly reduce the number of cooks needed to serve hot meals to troops on the battlefield. This author attended that briefing, and the General was positively impressed. Shortly thereafter, the General initiated a decision-making process that within about 2 years converted 5,000 cook positions into light infantry soldiers. This decision led to a very accelerated research-and-development cycle to convert a concept solely on paper into a fully developed, tested, and fielded system for feeding the entire Army before the cooks were taken out of the Army inventory.

The new CFFS-FDTE was based on the T Ration. The key new component of the system was a flat, rectangular, half-steam-table-sized metal can (tray pack) that contained 12 to 20 servings of shelf-stable, thermally processed entrees, vegetables, starches, or desserts. Each tray pack could serve as its own heating (in hot water) and serving vessel. The tray packs were configured with bread, beverage mixes, condiments, and disposable dinnerware in 36-meal modules. One of the major challenges to the ration developers was that an industrial base to produce the T Ration menu components with a nonrefrigerated shelf life of at least 3 years had to be developed and tested on an item-by-item basis. This necessity delayed the development of T Ration menus and the nutrient composition data to determine if the CFFS-FDTE ration would meet OTSG's nutritional standards (U.S. Departments of the Army, the Navy, and the Air Force, 1985) for operational rations.

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### 1985 CFFS-FDTE Test—Hawaii

In early 1985, General Maxwell Thurman, the Vice-Chief of Staff of the Army, assembled a room full of general officers and reviewed the status of issues necessary to begin implementing the CFFS-FDTE the following year. General Thurman asked if all the necessary testing had been completed. This author informed him that a field test had not been conducted to determine if troops would eat enough of the ration to meet their nutritional needs. General Thurman then turned to Major General Rapmund and said, "Doc, I want you to ensure this new ration gets adequately tested and fixed, if necessary, to ensure that we will maintain the health and performance of our soldiers when they have to eat this ration for extended periods. We may not have the cooks or the equipment there to serve them a freshly prepared, hot meal."

This tasking from the Vice-Chief of Staff of the Army became the first project for this author as the Director of the newly formed Military Nutrition Division at USARIEM. In conjunction with the U.S. Army Combat Developments Experimentation Center (USACDEC), USARIEM conducted the largest and most extensive field ration trial ever, involving over 1,600 troops from the Twenty-fifth Infantry Division at the Pohakuloa Training Area, Hawaii, during August to September 1985. Six different ration combinations of the T, A, B, and MRE rations were evaluated during the 44-d field trial.

Because this was an Army Operational Test, there was a requirement to define the test objectives, identify the issues, establish criteria, select test procedures, and assign responsibilities to collect, analyze, and evaluate the data in the test plan agreed to by all involved organizations prior to the start of the test. USACDEC was responsible for the operational and organizational plan effectiveness objective and the morale and ration acceptability objective. USARIEM was responsible for the nutritional adequacy and medical evaluation objective. The issues, criteria, and test procedures associated with that objective are briefly summarized in Table 6-4. Note that a separate issue was established to evaluate whether troops would consume sufficient calories to meet the energy demands of the field exercise and that a 3 percent body weight change criterion, with compensation for dehydration, was selected to evaluate this specific issue. The standard values of biochemical indices of acceptable, low, or deficient nutritional status that were used in this test are shown in Table 6-5.

The CMNR was closely involved in an advisory capacity during all phases of this test. Their suggestions were incorporated into the test plan, and a subcommittee of the CMNR (Robert Nesheim, Mark Hegsted, and Susan Berkow) came to the test site and reviewed the data collection procedures. The

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TABLE 6-4 Nutritional Adequacy and Medical Evaluation—1985 CFFS-FDTE Test

| Issue | Criterion | Test Procedure |
|---|---|---|
| CFFS-FDTE ration intakes adequate to meet MRDAs? | Average daily energy, protein, fat, vitamin, and mineral intakes of platoon should meet all RDAs. | Food and water intake data measured on 16 days during 44-d test. Nine-point hedonic ratings for each item consumed and reasons for nonconsumption recorded. |
| Will troops consume sufficient CFFS-FDTE rations to meet energy demands of field exercise? | With compensation for dehydration, average body weight loss or gain of platoon should not exceed 3 percent of initial body weight at any time during test. | Body weights measured accurately (± 0.2 kg) before and 2 × per day on 16 days during 44-d test. |
| Will troops fed CFFS-FDTE rations consume sufficient fluids and water to maintain hydration status? | Average urine specific gravities of a platoon should not exceed 1.030 at any time. | Overnight-fasting urine samples collected before and on 11 days during the 44-d test. Measured specific gravity, osmolality, and electrolytes and creatinine ratios. |
| Will troops maintain nutritional status? | No statistically significant ($P < 0.05$) increase in incidence of nutritional deficiency and no significant change in body composition, cholesterol or lipoprotein levels should occur. | Skinfolds; HDL, LDL, and total cholesterol and biochemical indices of acceptable, low, or deficient Vitamins A, C, thiamin, riboflavin, folic acid, and iron measured pre, and days 1, 20, and 44. |
| What is the incidence of food-related health disorders? | Investigative. | Environmental systems questionnaire administered before and once during each food intake collection period.<br>Monitor Medical treatment logs with follow up interviews of soldier complaints |
| Will muscle strength, muscular endurance, and eye-hand coordination be maintained? | Average strength endurance and coordination scores must not decrease more than 10 percent from initial values | Handgrip strength and endurance; maximal isometric upright pull force; maximal lift capacity; arm-hand steadiness; and ball-pipe test measured pre, and days 1, 20, and 44. |

SOURCE: Adapted from USACDEC/USARIEM (1986).

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TABLE 6-5 Standard Values Indicative of Nutritional Deficiencies

| Parameter | Age/Sex Category | Deficient Level (High Risk) | Low Level (Medium Risk) | Acceptable Level (Low Risk) |
|---|---|---|---|---|
| Vitamin A Plasma retinol (μg/100 ml) | All ages | <10 | 10–19 | ≥20 |
| Vitamin C Serum ascorbic acid (mg/100ml) | All ages | <0.20 | 0.20–0.29 | ≥0.30 |
| Thiamin red blood cell transketolase TPP effect, TPP* stimulation (%) | All ages | >20 | 16–20 | 0–15 |
| Riboflavin red blood cell glutathione Reductase FAD† effect (activity coefficient) | All ages | >1.40 | 1.20–1.40 | <1.20 |
| Folic acid Serum Folacin (ng/ml) | All ages | <3.0 | 3.0–5.9 | ≥6.0 |
| Hemoglobin (g/100ml) | Adult male | <12.0 | 12.0–13.9 | ≥14.0 |
| | Adult female | <10.0 | 10.0–11.9 | ≥12.0 |
| Hemocrit (%) | Adult male | <37 | 37–43 | ≥44 |
| | Adult female | <31 | 31–37 | ≥38 |
| Iron (three measures used deficiency = two of three abnormal) | | | | |
| (1) Transferrin saturation (%) | All ages except infant | <15.0 | 15.0–19.9 | ≥20.0 |
| | All adults | <16 | | ≥16 |
| (2) Erythrocyte protoporphyrin (μ/dl red blood cell) | 15–74 years | >70 | | <70 |
| (3) Serum ferritin (ng/ml) | 15–74 years | <12 | | ≥12 |

* TPP, thiamin pyrophosphate
† FAD, flavin adenine dinucleotide.
SOURCE: USACDEC/USARIEM (1986).

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CMNR also reviewed and provided comments on the preliminary data in December 1985 prior to publication of the three-volume CFSS-FDTE Test Report (USACDEC/USARIEM, 1986) in January 1986. Robert Nesheim also was present for one of the briefings on the test results to general officers in the Pentagon during February 1986. The findings, conclusions, and recommendations from this study were briefed to the Chief of Staff and Vice-Chief of Staff of the Army in March 1986. The nutritional findings were that the troops consumed sufficient quantities of the CFFS-FDTE rations to meet their energy demands and consumed sufficient fluids to maintain hydration status. Calcium intakes of the female soldiers did not meet the MRDAs. Recommendations were made and adopted by the Army to increase the variety and quality of T Ration breakfast entrees and starches to encourage greater consumption, to increase the calcium content of the T Ration menus, and to add a beverage powder to the MRE to encourage optimal hydration while troops were subsisting on three MREs per day. The CMNR's comments and recommendations were included in their 1986 Annual Report (NRC, 1986).

## 1986 MRE Improvement Test—Hawaii

The next major field trial was the 1986 MRE Improvement Test, an 11-d field test conducted by USANRDEC and USARIEM to evaluate the effectiveness of MRE improvements to correct previously identified problems with inadequate consumption, excessive body weight loss, and possible dehydration. Because this test was of relatively short duration (11 days), the nutritional variables were limited to measuring energy, nutrient, and fluid intake; body weight change; and urine specific gravity for small groups of soldiers fed the current version of the MRE three times per day or two different versions of an improved MRE. The same body weight loss and hydration status criteria that were used in the 1985 CFFS-FDTE test were used in this test.

Results of the 1986 MRE Improvement Test (Popper et al., 1987) were also briefed to a General Officer Committee for a decision on whether to stay with the current MRE or to adopt one of the improved versions. Soldiers fed the improved MRE consumed more calories, lost less body weight, were better hydrated, and drank more total water than the current MRE group. The decision was made to incorporate the improvements that worked (e.g., add the beverage powder, increase the size of some of the entrees) into the next annual procurement of the MRE. This author raised the point at that briefing that energy intakes of the improved MRE, although increased by 325 kcal/d, were still approximately 700 kcal/d below the energy expenditures of the light infantry soldiers and that further improvements were still needed. Although the improvements in hydration status noted in this temperate environment test were encouraging, this author also noted that similar tests should be conducted in

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more demanding hot and cold climates where problems with dehydration are more likely to occur.

### 1989 MRE Cold-Weather Supplement Test—Alaska

The 1989 MRE Cold-Weather Supplement Test was a 10-d field trial conducted by USARIEM and USANRDEC to evaluate the effectiveness of current and improved MRE rations, with or without a supplement, to maintain body weight, nutrient intakes, and hydration of light infantry soldiers conducting field training in extreme cold (-40¹F to +30¹F; -40¹C to -1¹C) temperatures. The nutritional criteria for this test were identical to those used in the 1986 MRE Improvement Test. The results (Edwards et al., 1990) indicated that the supplements increased energy intakes by approximately 700 kcal/d and reduced body weight losses to approximately 1.8 percent of body weight over the short 10-d period.

During the third and fourth days of this field trial, two of the units that were receiving the supplements had average urine specific gravities exceeding the 1.030 criterion. The urine specific gravities were high because the soldiers were consuming only about 1 to 1.5 liters of fluid per day compared to 3 to 4 liters per day for the other two groups. Upon investigation, the problem did not appear to be due to the supplement, but rather to a logistical problem. The two units did not get resupplied with unfrozen water, and they did not have the equipment with them to melt snow. Fluid intakes and urine specific gravities returned to normal as soon as the water resupply problem was resolved.

## RECOMMENDATIONS

This author's experiences during the past 10 to 12 years of direct involvement in establishing nutritional criteria for field testing of operational rations have led to the following recommendations:

- Nutritional standards for operational and restricted rations are appropriate nutritional criteria for development and procurement of military rations.
- Military Recommended Dietary Allowances (MRDAs) are the appropriate criteria for the evaluation of the nutritional adequacy of nutrient intakes of male and female personnel who consume operational rations in field.
- Field tests to determine if troops will consume more of one ration than another should be a minimum of 10 days in duration.
- Field tests to evaluate whether troops will eat enough of the ration to meet their energy demands should be a minimum of 14 days but preferably 21- to 30-d duration.

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- The appropriate criterion to evaluate whether troops will eat enough of the ration to meet their energy demands should be that the average body weight loss of the test unit does not exceed 3 percent of initial body weight.
- An acute (1 to 2 days) average weight loss exceeding 3 percent is indicative of possible dehydration.
- An average urine specific gravity exceeding 1.030 is indicative of inadequate fluid consumption and possible dehydration.
- Average body weight losses for a unit of troops exceeding 5 percent of initial body weight may indicate an unacceptable risk of adverse health or performance.
- Individuals who lose more than 10 percent of initial body weight during a field ration trial should be immediately referred for medical evaluation.
- Field ration trials of more than 21-d duration should include biochemical assessment of nutritional status.
- A new or major modification to an existing ration or feeding system should not to be implemented until it has been adequately tested in direct comparison with the old ration or system with troops during realistic field training maneuvers.
- Field ration trials should also be conducted under extreme environmental conditions.

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# 7

# Evolution of Rations: The Pursuit of Universal Acceptance

*Gerald A. Darsch*[1] *and Philip Brandler*

## INTRODUCTION

The logistical task of providing subsistence for military personnel has been critical throughout history. Frederick the Great of Prussia is credited with having defined an army as a group of men who demand daily feeding (Frederick II, 1966). Military rations are no less important today, and, in fact, the importance of sound nutrition to the performance of modern, high-technology military personnel may be even more critical than in the past. Simply put, food fuels the fighter, and inadequate fuel for fighters will bring the military machine to a grinding halt.

The U.S. Army Natick Research, Development and Engineering Center (NRDEC) is responsible for the Department of Defense (DoD) Food Research Development Test Evaluation and Engineering (RDTE&E) Program. The DoD Food RDTE&E Program was established as a joint service program at NRDEC to provide for a coordinated and integrated program supporting the requirements

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of the four services and other DoD components. The food program encompasses the design, development, and evaluation of new and improved operational rations, packaging, foodservice equipment, and feeding systems.

## OPERATIONAL RATIONS

The American military addresses the task of feeding its personnel with a family of operational rations that are designed to provide necessary nutrition regardless of the tactical situation. The family of rations is currently composed of the Meal, Ready-to-Eat (MRE), which is the standard individual combat ration, and three field feeding options, which provide hot group rations to soldiers: Tray Ration (T Ration), B Ration, and A Ration.

Numerous constraints and considerations must be addressed by a ration developer, particularly in the case of individual combat rations, if an acceptable ration is to be provided to American military personnel. Six constraints that must be addressed by any developer of food products are:

- acceptance,
- nutrition,
- wholesomeness,
- producibility,
- cost, and
- sanitation.

In addition, 10 constraints that are unique to the military must also be addressed by developers of rations. They are:

- *Universal acceptance*. Goya Foods, for example, targets customers with Hispanic heritage. Its products are selected and prepared in accordance with the tastes and expectations of this niche of the wholesale and retail food market. The American military, however, draws its population from ethnic backgrounds representing just about every nation in the world and, further, from all regions of the United States. Because these regional and ethnic preferences must be considered, the selection and formulation of specific products for military rations are difficult tasks.
- *Worldwide environments*. The U.S. Army has, and in the future will increasingly be, a force projection army, that is possess the capability to effectively move large numbers of U.S. based troops to any global location to engage in combat and win decisively. As a result both personnel and material, particularly food and related supplies must be transportable and consumable in any environment in the world. Although many manufacturers can package their items for a specific local market, American military rations must be formulated and packaged to be shipped, stored, prepared, and consumed in temperatures ranging from -60$^1$F to 120$^1$F (-51$^1$C to 49$^1$C).

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- *Air delivery*. While American food processors must package their products to ensure protection during rail or truck transportation, the American military often must deliver its rations to combatants by air. Air delivery involves not only the considerations necessary for air cargo transport, but also those for parachute drop or even free fall. Therefore, rations must be packaged to withstand extremely rigorous and rough handling.
- *Weight and volume*. American food processors are eagerly striving to remove as many calories as they can from products they prepare and market. In contrast, the American military must be concerned with maximizing the caloric content of food products while minimizing the weight and volume. In most cases, a force projection army must transport its own food and cannot afford to waste valuable space on board aircraft and ships to store bulky food items. Further, once the Army is deployed into the field, neither space nor weight can be wasted on trucks or in the load-bearing equipment of individual soldiers.
- *Shelf life*. A minimum shelf life of 3 years at 80¹F (26.7¹C) is required in order for rations to be placed in prepositioned war reserve stocks. This extended shelf life—as opposed to commercial shelf life, which is 18 months—is necessary for two reasons. First, a shrinking Army may require that rations remain in prepositioned war reserves for longer periods of time since the available number of military consumers of that stock will shrink. Second, extended shelf life ensures that the quality of rations can be maintained for long periods of time in high heat environments, which reduce considerably the shelf life of food products.
- *Self-heating*. Self-heating ensures that soldiers will have hot meals at all times with a consequent increase in acceptance and consumption of the food items presented. In many cases soldiers simply do not have the time to stop and conventionally heat a ration.
- *Performance enhancement*. The Army would like to use the ration as a force multiplier for its soldiers by providing naturally occurring food ingredients to extend the mission endurance of each individual combatant. Research indicates that specific nutrients provided in appropriate quantities can enhance performance, both physical and cognitive (QMC&S, 1994), and this avenue is being explored aggressively.
- *Modularity*. Modularity involves the construction of a nutritionally complete ration using preassembled subcomponents. It permits tailoring of ration systems capable of meeting a broad range of requirements through interchanging a small set of ration components.
- *Boredom*. Limitations in the logistics system require that the menu cycle length be restricted. The military transportation assets, specifically aircraft, ships, and vehicles, are limited in number and must transport all combat equipment and supplies to include food. Because of the physical space constraints coupled with the necessity of maintaining a manageable inventory, a 10-d menu cycle has been established by the Army. Therefore, items must be selected from the menu cycle in an appropriate time cycle to delay menu boredom for as long as possible.

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- *Biological and chemical threats*. Although military rations have historically been packaged and processed to avoid the possibility of biological contamination from naturally occurring organisms, war-time scenarios of the future suggest that rations might become contaminated by the effects of biological and chemical warfare. Military rations must be packaged to counter those threats.

## CURRENT AND FUTURE OPERATIONAL RATIONS

### Meal, Ready-to-Eat

The Meal, Ready-to-Eat (MRE) is an operational ration currently configured as 12 menus, with all 12 menus packaged together in a shipping case. Each menu weighs 11/2 lbs (0.7 kg) and comprises six to eight components. Most of the components are packaged in flexible trilaminate material, and some of the components, the entree for example, are retort processed[2] to achieve commercial sterility. All components are nutritionally balanced in accordance with the Office of the Surgeon General's (OTSG) requirements as stated in AR 40-25 (1985). The MRE is intended for use in conflict situations where cooks cannot prepare group meals by virtue of the tactical environment.

The first date of pack for the MRE was 1981 (MRE I). In 1983 a field evaluation was conducted with the 25th Infantry Division over a 34-d period in which the military personnel involved ate nothing but MRE Is three times a day. Although troops rated the ration as acceptable, consumption rates were low: only about 60 percent of the calories provided were actually consumed. However, the exercise resulted in numerous suggestions on how to improve the MRE I.

During a follow-on field evaluation in 1986 of an improved MRE, again with the 25th Infantry Division, both acceptability and consumption of the MRE increased as a result of the improvements made. Based on these findings, a significant number of changes were made to the MRE starting with the 1988 date of pack (MRE VIII). These changes included replacing 9 of the 12 entrees with new ones, increasing entree size from 5 to 8 oz (from 143 g to 229 g),

[2] Packaged foods heat treated (e.q., 250¹F) under pressure (e.q., 15 psi) for sufficient time to inactivate food microorganisms. Examples of foods that require retort processing include low acid foods with sufficient moisture (e.g., entrees, vegetables, starches, and desserts) to support the growth of microorganisms.

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adding commercial candies to 4 more menus, adding hot sauce to 4 menus, and adding a cold beverage base to all 12 menus.

The process of MRE improvement has continued based on surveys of troop feedback from the field, including early feedback from Operation Desert Shield/Storm (ODS); from focus groups; and from individual interviews with soldiers. As a result starting with MRE X, commercial freeze-dried coffee replaced the old military specification spray-dried coffee, hot sauce was added to all 12 menus, wet pack fruit was provided in place of dehydrated fruits, and commercial candy was included in four more menus for a total of 8 menus with candy.

During ODS, MREs were eaten by many troops for periods far in excess of their design. The surgeon general had endorsed the use of MREs as the sole source of food for periods of 10 days or less; however, during ODS troops had to subsist on MREs for periods of up to 60 days or longer. As a consequence during the operations, three changes were quickly made either to supplement the MRE or to enhance its acceptability. All three items were procured in bulk and provided to members of the Armed Forces during ODS. First, a shelf-stable bread in a standard MRE pouch was developed. Through the innovations of water activity control, new ingredients, and intrapackage atmosphere management, this bread can remain in a fresh-list state for up to 3 years (Brandler and Darsch, 1993). Second, a high-heat-stable chocolate was developed, in coordination with industry, that would not melt in the heat of the desert environment, and that would be highly palatable. While a high-heat-stable chocolate had been developed in the past, its waxy taste and nature precluded its high acceptance. A third development was the flameless ration heater, which uses an exothermic chemical reaction to produce heat rather than a flame (Brandler and Darsch, 1993). This device provided a quick and easy method for troops to heat the MRE entree, which increased both its acceptance and consumption rate.

Despite these innovations and the earlier improvements made to the MRE, the ration was not without criticism during ODS. Because it was necessary to use prepositioned was reserves, some rations provided to soldiers during ODS were 4 to 5 years old or even older, and many had been subjected to cycles of temperature that had accelerated the degradation process. In some cases difficulty in maintaining the logistics chain for A, B, or T Rations, specifically the inability to provide foodservice equipment to prepare bulk food, precluded the use of group feeding options. As a result, soldiers had to subsist on MREs for extended periods of time. This problem was further exacerbated by command decisions in some divisions whereby MREs had to be eaten by all division members if even one soldier had to eat it by virtue of his tactical situation. As a result, opportunities to provide variety in food options to troops (e.g., group meals) were ignored. An after-action analysis conducted during a Joint Service MRE Forum established in 1991 to review the performance of the MRE during ODS concluded, however, that the MRE was not problematic

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when used properly. This group suggested that a policy of replacing up to 2 menus per year of the 12 provided in each case would ensure that new items would be available when the MRE is used. Since its establishment in 1991, the Joint Service MRE Forum (now referred to as the Joint Services Operational Rations Forum [JSORF]) is held once a year to continue to endorse enhancements to the MRE.

This recommendation of the Joint Service MRE Forum underscored NRDEC's commitment to a policy of continuous product improvement for the MRE and permitted acceleration of the testing and fielding of new innovations through the Soldier Enhancement Program (SEP)[3]. Beginning in FY 1991, and continuing, a number of new MRE menus are tested each year with soldiers in field environments who are deployed on field training exercises. The results are presented to the Army's Subsistence Review Committee (SRC), which is chaired by the deputy chief of staff for logistics. Following his approval, the recommendations are presented to JSORF, with representatives from each of the Armed Services, for endorsement by the JSORF. Specific changes in the MRE that have resulted from this process since FY 1991 include the following:

- chicken a la king and barbecued meatballs were replaced with smokey franks and pork chow mein in both MRE XIII and XIV;
- smokey franks and pork chow mein were supplemented with new snacks: potato sticks and chow mein noodles, respectively;
- highly dense nut cakes were replaced with pound cakes in five different flavors in three menus;
- six of the 12 Kool-Aid style beverages were replaced with aspartame-based fruit flavors; and
- a flameless ration heater was included with all MRE menus to ensure that a heating capability was provided with the meal.

As a result of follow-on field testing during 1992, SRC and JSORF decisions on MRE XV included the following:

- ham omelet and corned beef hash were replaced with grilled chicken breast and chili macaroni;
- a third snack, tavern nuts, was added to the menu cycle;
- the old style brownie was replaced with a new chewy brownie;
- a freeze-dried fruit was replaced with wet pack pineapple; and
- six of the freeze-dried coffees were replaced with sweetened lemon tea.

[3] The Soldier Enhancement Program is a U.S. Army program designed to accelerate the identification, field testing, and introduction of new items (with an emphasis on commercial off-the-shelf products) into the supply system to enhance the quality of life of soldiers.

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Many of the items now included in the MRE are standard commercial items. In fact, 44 percent of the MRE components, including some of the new entrees, are commercial items.

During ODS, the Armed Forces Chaplain Board identified yet another need for ration development to meet the needs of personnel with specific religious dietary observances and restrictions. As a result, the development of a Multi-Faith Meal (MFM) was endorsed by the SRC and the JSORF in FY 1993. Pending SRC and JSORF approval, up to two MFMs per MRE shipping case will be included in MRE 1996 date of pack and will replace two of the less acceptable MREs.

Six MFMs have been designed utilizing nondevelopmental, commercially available kosher and vegetarian entrees and compatible MRE components. These meals were the subject of field tests during the first quarter of 1994 with military personnel of the 18th Airborne, Fort Bragg, and of the U.S. Marine Corps, Camp Lejuene. Military personnel both with and without religious dietary restrictions were tested to ensure universal acceptability.

The NRDEC program of continuous MRE improvement continued with a field test in the fourth four entrees, breaded chicken, grilled beefsteak, chicken parmigiana, and Hawaiian chicken; two starches, buttered rice and Mexican rice; and a new spread, jalapeño cheese. In the first quarter of 1994 a number of packaging improvements were also field tested. These included:

- commercial-like graphics and logos since behavioral data indicate that commercial packaging results in greater acceptance and consumption;
- incorporation of easy-open features since existent MREs are somewhat difficult to open;
- utilization of horizontal form, fill, and seal packaging, which decreases the bulk of and facilitates ease of carrying the meal; and
- incorporation of a biodegradable spoon to make the MRE more environmentally friendly.

Those changes that are implemented will probably affect MRE XVII.

In FY 1994 NRDEC also began an analysis of the effects of increasing the number of MRE menus from 12 to 18 to 24 as a strategy to overcome menu monotony and to allow the use of the MRE as a sole source of food for extended periods of time. The analysis will identify, and validate through field testing, the optimum number of menus that positively affect consumption of the MRE. Data will be presented to the OTSG, SRC, and JSORF so that changes to MRE XVIII and beyond can be made.

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## Tray Rations

The most tactically versatile of the group rations is the Tray Ration (T Ration), which is made up of heat-and-serve prepared foods in half-steam-table-sized rectangular cans. Each meal is nutritionally balanced in accordance with AR 40-25 (1985) and includes an entree, a vegetable, a starch, and a dessert. The T Ration provides hot group meals with limited personnel and minimal equipment.

First introduced in FY 1985, the T Ration initially provided a 14-d breakfast and a 14-d lunch-dinner menu. All necessary components, including napkins, knives, forks, trays, and so on, were contained in modules for 36 military personnel. A field test in FY 1989 that evaluated a 14-d menu versus a 10-d menu provided a baseline assessment in a temperate environment. Because the 14-d did not seem to provide any significant benefit, the T Ration was converted to a 10-d menu. Entrees in the 10-d breakfast menu include sausages, creamed ground beef, and a variety of omelets. The lunch-dinner entrees include such items as solid muscle chicken breast, lasagna, and ground beef pattie with a shelf-stable roll.

In FY 1991 the module size of the T Ration was reduced from 36 to 18 soldiers since the 36-person module was simply too heavy for an individual soldier to handle. Also, in FY 1991 an 18-soldier arctic module supplement was added to the T Ration system to provide the additional calories required in cold weather operations. The arctic module augments the standard 18-soldier module with additional hot beverages, snacks, and specialized clam shell type trays that help with heat retention of the food.

The T Ration has been the subject of a product improvement program at NRDEC, and menus have been restructured on a continuous basis to eliminate less acceptable items and to add new, more highly acceptable items. All substitutions are made on the basis of field tests in the same manner as with the MRE. New T Ration components recently developed and field tested include a new family of high-quality, freeze-dried scrambled eggs, chicken teriyaki, and boneless barbecued pork ribs. As with the MRE, the data are presented to the SRC, JSORF, and OTSG for endorsement and approval.

## B Ration

Another group ration is the B Ration, a cook-prepared meal that requires a field kitchen. However, all ingredients used to prepare the B Ration are semi-perishable, and therefore, no refrigeration is required. Most of these semi-perishable ingredients are standard institutional-type ingredients such as flour, sugar, and large (# 10) cans of vegetables and meats. In addition, there are 13 unique items that are either dehydrated or chunked and formed. Preparation of these meals in the field using field kitchens is a demanding task

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that requires considerable culinary skill. The B Ration has not changed substantially since the 1970s; therefore, a modernization program is under way. Advancements in ingredient and food processing technology will be incorporated to increase quality and reduce cost. The 10-d breakfast and dinner menus of the B Ration are prepared using the Armed Forces Recipe Service.

### A Ration

The third and final group ration is the A Ration, which is a meal prepared by cooks in a field kitchen where refrigeration is available and chilled and frozen products can be provided. Like the B Ration, this meal requires considerable cooking skill and demands careful inventory management due to both the perishable nature of some ingredients and the total number and quantity of ingredients required to prepare and serve meals. Like the B Ration, the 10-d menu of the A Ration is prepared using the Armed Forces Recipe Service.

### Unitized Group Ration

To simplify the logistics of ordering and to ensure that all necessary ingredients to prepare group rations are provided, an integrated unitization concept called the Unitized Group Ration (UGR) has been developed by NRDEC in conjunction with the U.S. Quartermaster Center and School (QMC&S) at Fort Lee, Virginia. The UGR integrates into a unified system the A Ration minus the perishables, the B Ration, the T Ration, and additional brand-name items that can be quickly prepared. The UGR contains 15 breakfast menu options (5 each of rations A, B, and T) and 30 lunch-dinner menu options (10 each of rations A, B, and T). Each of the meal options is unitized in six containers and provides all of the ingredients, trays, utensils, napkins, condiments, and so on, necessary to feed 100 military personnel. The six containers make up one layer of a pallet, and four layers constitute a pallet load. This system maximizes the efficiency of group feeding in the field and reduces the number of individual food components (e.g., canned meat, flour, salt, pepper, tomatoes, etc.) a cook must order to prepare a meal to one-tenth the number formerly required.

The UGR has been evaluated in a series of four field trials, which have indicated that the UGR simplifies logistics and significantly reduces the issue time to deliver rations to field units. The UGR also accommodates the Chief of Staff, Army-approved recommendation that one A or B meal be served to troops in the field, if the mission, enemy, troop, terrain, and time permit (QMC&S, 1994). A future field test will evaluate what has been designed to be an optimized configuration for the UGR with the maximum number of

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acceptable ingredients and menu options incorporated. Pending approval the UGR will go to the Defense Personnel Support Center no later than the second quarter of 1995 for procurement.

## NUTRITIONAL LABELING

Nutritional labeling of operational rations is an area of concern for ration developers. The need for nutritional information by military personnel has been identified not only by direct feedback from personnel but by the Office of the Surgeon General and the Committee on Military Nutrition Research (IOM, 1991). During Operation Desert Storm/Shield, troops requested nutrient information, and it became clear that many were misinformed about their rations, particularly with respect to nutritional content. A program is now in place to develop guidelines and labeling concepts for rations that are in accordance with nutrition policy and recommendations of the U.S. Food and Drug Administration, the U.S. Department of Agriculture, OTSG, and the military. An appropriate user evaluation of nutrition labeling concepts will be conducted by NRDEC to ensure that the military consumer finds them useful. Pending approval, modified nutrition labeling will be included in or on operational rations in the future.

## FUTURE FIELD FEEDING CONCEPTS

A technology-based program is under way at NRDEC that addresses a new family of operational rations intended to meet the food needs of the future battlefield. The effort is aimed at developing self-heating rations that have fresh-like quality, yet are shelf stable and suitable for both individual and group feeding. The two major components of this ration system include a self-heating individual meal and a self-heating group meal. These particular meal concepts will be tested, fielded, and further improved through technology changes in processing, packaging, and heating. Incorporation of this technology into the rations system is scheduled for sometime after the year 2000.

For the self-heating individual meal, developers are seeking to utilize a tray or shallow tub configuration similar to individual commercial tray meals such as Top Shelf meals, manufactured by Hormel Incorporated. The meals are designed to be nutritionally complete, including a meat, vegetable, starch, and dessert. Entrees consist of popular foods such as whole muscle meats. One of the concepts under consideration calls for the integration of both the heater and activating solution in the meal package so that the soldier does not have to add water to the package to initiate the heating process. An initial demonstration with limited technology was completed in 1993 with positive results. Pending further technology development, demonstration, and military services approval,

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the concept is scheduled to move into advanced development sometime in FY1996.

The self-heating group meal ration system, also referred to as "a kitchen in a carton," will require no foodservice equipment. Food components (e.g., entree, vegetable, starch, and dessert) will each be contained in large, 6.6-lb (3-kg) retort pouches. Heaters built into the trays that hold the retort pouches[4] will "fuel" a canteen of water that is automatically metered to the various heating pads in the trays. The heating system will ensure that each food component will be hot in 30 minutes and will remain hot for an additional 5 to 6 hours if needed. Meal modules will include all accessories and utensils in the same way described earlier for the modularization of UGR and T Rations, and each module will provide a complete meal for 18 soldiers. An initial demonstration of the self-heating group meal to military foodservice personnel was completed in 1993 with positive results. This meal concept is scheduled to move into advanced development in FY1996.

## CONCLUSION

As the United States is the most technically advanced country in the world with respect to weapon systems, so too are the ration systems that have been fielded and that are currently under development. Success in the development of these rations is due not only to the technology programs conducted by the U.S. Army Natick Research, Development and Engineering Center, but also to the feedback received from military personnel; to the nutritional scientific evaluations and analyses conducted by the Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine; and to the guidance provided by the office of the Surgeon General and the Committee on Military Nutrition Research. Although considerable strides have been made in improving the quality, variety, and acceptability of operational rations, rigorous efforts must continue to meet the changing food habits and expectations of the soldier, sailor, airman, and marine.

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AR (Army Regulation) 40-25 1985. *See* U.S. Departments of the Army, the Navy, and the Air Force.

[4] Retort pouches serve as the primary food container. The pouches are flexible in nature and are constructed of a trilaminate material consisting of polyethylene as the food contact layer, a thin layer of aluminum foil, and polyester.

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## DISCUSSION

ROBERT NESHEIM: Thank you very much. All I can say is that I was involved in World War II 50 years too early.

BARBARA ROLLS: Do soldiers have the ability to self-select the MREs that they want?

GERALD DARSCH: It depends on how fast you run! There are 12 meals in the case, and the soldiers know which number pertains to which meal. In some cases, foodservice personnel will just dump the case upside down. Peter Motrynczuk can answer this better than I, but if you are there quicker, you might get the meal you want before the last guy shows up.

PETER MOTRYNCZUK: Normally they will have a case open, and there are numbers that appear on meals. Because soldiers get to know what number is what, they will be selective if they have that opportunity. But most managers will not open another case until one case is completely emptied.

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# 8

# Overview of Dietary Intakes During Military Exercises

*Carol J. Baker-Fulco*[1]

## INTRODUCTION

Nutrition influences how well a soldier can train and fight. An optimal diet may be helpful in delaying fatigue, improving performance during training or combat, and avoiding injuries, while certain nutrient deficiencies can seriously impair performance. Military rations provide for the nutritional needs of the majority of service members; unfortunately, what is provided is not always consumed. If soldiers do not consume adequate rations, mental and physical performance and morale may suffer.

The purpose of this chapter is to present an overview of results of many ration consumption studies conducted by the Military Nutrition Division

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(MND) so that the Committee on Military Nutrition Research can put the issue of underconsumption of rations into perspective and determine what interventions are warranted. Is there really a problem? If so, is underconsumption a problem of such magnitude as to threaten health or performance, or is the problem mainly one of degrading morale or wasting of food dollars?

## METHODS

MND conducts ration tests in the field, using troops in their usual environments while they perform their everyday military duties. Most ration studies are performed to assess the nutritional impact of a prototype or an improved version of an operational ration. Data have been collected mostly from men, ages 19 to 30 years. Mean body weights have ranged from 75 to 81 kg. Study durations have varied from 5 to 30 days, although most studies lasted 7 to 10 consecutive days. One major exception was the Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) conducted in Hawaii in 1985, which recorded food intake on days 2, 3, 6, 7, 12, 13, 18, 19, 24, 25, 30, 31, 36, 37, 42, and 43 of a 44-d field exercise (USACDEC/USARIEM, 1986). In all of the other field studies summarized in this chapter, although the study duration varied, data was collected on consecutive days.

In studies when most food intake was obtained from military dining facilities or when hot meals were served in the field, the dietary intake data were usually collected by visual estimation. For this method, the test subject presented his or her tray to a data collector before sitting down to eat. The data collector recorded the food items and visually compared the portion sizes of foods on the subject's tray to a weighed standard of the same food. The data collectors were trained to estimate portion sizes to within 10 percent. After the meal, the test subject returned to the data collector, who recorded the quantity of food remaining on the tray. Foods consumed outside the dining facility were recorded by the subject on food records.

For studies of individual field rations, dietary intakes were also obtained by self-recorded food record. Cards that were precoded and printed with the menu items were provided to the subjects. The subject had only to circle the proportion of a serving consumed next to the appropriate menu item. There were separate prompts for recording canteens or cups of water. When it was important to determine water intake accurately, subjects were provided with graduated bottles or canteens to measure their fluid consumption. A food record is a reasonably accurate method of collecting food intake data because ration items are individually packaged, single serving-sized pouches or bars. When the test subjects were accessible, dietitians collected and reviewed the

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food records with the subjects daily. In some situations, the subjects were not accessible, and therefore, weekly log books were used.

## LIMITATIONS

While the MND studies collectively represent dietary intakes in the military, they cannot be used to look at trends or changes in dietary intakes. Although the study samples often represented large segments of the military, they were not random samples of military personnel. The number of test subjects was often small, and data were often collected for only a few days at the beginning of a field exercise. The data should thus not be interpreted to represent usual dietary intakes of the populations studied. Rather, the data reflect the exact nature and quantity of individual foods consumed within defined periods of time. The data collected do not account for intraindividual variations due to day of the week (weekday or weekend) or season of the year. Many studies did not record or analyze intakes of commercial or nonration foods ("pogey bait"). In addition, the ration composition data are based on few samples and do not reflect losses that would occur due to prolonged storage.

## RESULTS AND DISCUSSION

### Dietary and Energy Intakes in Garrison

Table 8-1 shows typical energy, carbohydrate, and protein intakes of MND study groups in garrison. Garrison studies evaluate soldiers' intake patterns in a more free-living situation while they perform their daily jobs and eat at least some of their meals in the dining facility on post. The results in Table 8-1 of the Fort Lewis and the two Fort Devens studies differ from the figures published in the original technical reports (Szeto et al., 1987, 1988). These reports did not include foods consumed outside of the dining facility, nor did they present mean total dietary intakes. The daily means reported were totals of the mean breakfasts, mean lunches, and mean dinners of whichever study participants ate those meals. The data were subsequently reanalyzed for mean total dietary intakes and for foods consumed outside of the military dining facilities. The corrected data for these four studies are reported in Table 8-1.

Soldiers do not necessarily consume less in the field than in garrison. Energy intakes in garrison have ranged from 2,730 kcal at Fort Lewis to 3,260 kcal at Fort Devens. Except for a slightly lower energy intake by the Fort Lewis group, energy and protein intakes met Military Recommended Dietary Allowances (MRDAs) (AR 40-25, 1985). Energy intakes were relatively high

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compared to a mean energy intake of 2,667 kcal for men aged 19 to 34 years in the 1985 Nationwide Food Consumption Survey-Continuing Survey of Food Intakes by Individuals (NFCS-CSFII) (USDA, 1986).

TABLE 8-1 Mean Dietary Intakes of Military Men in Garrison

| Year | Location | *N* | Study Duration (days) | Energy (kcal) | Carbohydrate (g) | Protein (g) | Reference |
|---|---|---|---|---|---|---|---|
| 1986 | Ft. Lewis | 31 | 6 | 2,730 | 313 | 103 | Szeto et al., 1987 |
| 1987 | Ft. Devens | 54 | 7 | 3,260 | 400 | 114 | Szeto et al., 1988 |
| 1988 | Ft. Devens | 51 | 8 | 3,131 | 353 | 126 | Szeto et al., 1989 |
| 1991 | Ft. Chaffee* | 32 | 30 | 2,901 | 358 | 125 | Thomas et al., unpublished † |

* Ft. Chaffee garrison data consist of total dietary intakes of the control group for a 30-d Meal, Ready-to-Eat (MRE) study. This group consumed two meals in a dining facility. They were provided 1 MRE/d for consumption at the worksite.
† C. D. Thomas et al., U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data.

MND also has studied students in military academy or school situations, where the subjects were more restricted, were typically required to attend all meals in the dining facility, and generally were more physically active than when in their usual jobs. Results of these studies are shown in Table 8-2. Study populations have been cadets at West Point; students of the Noncommissioned Officer Academy at Fort Riley, Kansas; enlisted basic trainees at Fort Jackson, South Carolina; and Marine Officer Candidates at Quantico, Virginia. The high energy intakes reflect the high levels of physical activity inherent in the training schedules of these schools.

Dietary intakes in garrison and academy situations have been presented as a reference point with which to interpret intakes in the field. They show the relatively high energy intakes when service men are not in the field. Unwanted weight gain is often a problem in garrison, while weight loss is typically observed in field situations. Depending on the quantity of physical training and the ease of obtaining food, either undesirable weight loss or weight gain tend to occur in academy or school situations.

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TABLE 8-2 Mean Dietary Intakes of Military Men in Academy or Training Situations

| Year | Location | *N* | Study Duration (days) | Energy (kcal) | Carbohydrate (g) | Protein (g) | Reference |
|---|---|---|---|---|---|---|---|
| 1979 | West Point | 136 | 5 | 3,738 | 432 | 125 | Kretsch et al., 1986 |
| 1986 | NCO* Academy | 43 | 8 | 3,199 | 387 | 124 | Carlson et al., 1987 |
| 1988 | Enlisted Basic | 41 | 7 | 3,199 | 410 | 125 | R.W. Rose et al., 1989 |
| 1990 | West Point | 119 | 7 | 3,564 | 482 | 130 | Klicka et al., 1993 |
| 1990 | Marine OCS † | 121 | 5 | 4,430 | 559 | 160 | Baker-Fulco et al., 1992 1992 |
| 1991 | Marine OCS | 162 | 5 | 4,647 | 706 | 169 | Baker-Fulco et al., 1994 |

* Noncommissioned Officer.
† Officer Candidate School.

## Dietary and Energy Intakes in the Field

Table 8-3 presents the abbreviations used for military operational rations and a brief description of the rations. Energy requirements during field exercises are probably as high as during the academy or school situations, yet much lower energy intakes were found (see Table 8-4). For most of these studies, the high end of the MRDA energy allowance range was used (i.e., 3,600 kcal) to assess adequacy. For the Fort Hood study, in which physical activities were only moderate, 3,200 kcal was selected as a better criterion.

The only field study group that met the energy allowance was the Fort Sill group. Due to a last-minute moratorium on the Meal, Ready-to-Eat (MRE), this group received three hot A Ration meals while engaged in sustained operations. Not only did they receive three hot meals, but because hot meals were trucked out at specific times, meal times were scheduled, and the troops were given ample time to eat. This is the only field study that showed a mean weight gain by the subjects. The Fort Sill study clearly illustrates the benefit of providing scheduled, hot meals.

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TABLE 8-3 Military Rations

| Ration | Description* |
|---|---|
| A | Perishable, semi-perishable, and staple foods served in garrison dining facilities. *A* Rations require refrigeration facilities and trained cooks. |
| B | Canned or dried foods not requiring refrigeration but requiring trained cooks to prepare. |
| T (Tray Pack) | Fully cooked, canned foods requiring only reheating. Used when group feeding is possible, but trained cooks and refrigeration are not available. |
| MRE (Meal, Ready-to-Eat) | Individual operational ration. Three menus per day provide an average of 3,900 kcal. The *MRE* has gone through numerous revisions since introduction. The version number refers to date of packaging. |
| RCW (Ration, Cold Weather) | Individual operational ration designed for cold-weather operations. Consists of low-moisture foods to avoid freeze-thaw damage and contains less protein and sodium to conserve body water. |

* For more detailed description of each ration, see Darsch and Brandler (Chapter 7 in this volume).

Most of MND's ration studies revealed a variable weight loss during field exercises. Although no ration group in the 1985 Hawaii study of the Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) lost greater than 3 percent of initial body weight, many individuals lost more than 5 percent of body weight during the 44-d field exercise. Approximately 9 percent, 10 percent, and 17 percent of men in the 2:T Ration, 2:A Ration, and 1:T Ration groups, respectively, lost more than 5 percent of their initial body weight. Thirty-seven percent of the men in the 2:B & 1:MRE group lost greater than 5 percent body weight.

Although the energy intake of the Fort Hood group was lower than the allowance, the group, as a whole, maintained body weight. This relatively high energy intake was partly attributable to the widespread availability of commercial snack foods. Between-meal foods and fluids accounted for 25 percent of the total energy intake. Only 44 percent of the MRE meals were consumed (Rose, 1989).

The very low energy intakes seen in the Bolivia study were probably due to the effects of altitude-induced anorexia. Abrupt exposure to high altitudes often results in symptoms of acute mountain sickness. These symptoms include headache, anorexia, nausea, vomiting, and malaise, all of which can interfere with the desire to eat. Food intakes are usually reduced 10 to 50 percent during acute altitude exposure (Askew, 1993). However, even after the symptoms of acute mountain sickness subside, depressed food intakes persist (Baker et al.,

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TABLE 8-4 Mean Dietary Intakes and Weight Loss of Military Men during Field Studies

| Ration | Year | Environment and Location | *N* | Study Duration (days) | Energy (kcal) | Carbo-hydrate (g) | Protein (g) | Weight Loss (%) | Reference |
|---|---|---|---|---|---|---|---|---|---|
| A | 1986 | Temperate, Ft. Sill, OK | 31 | 8 | 3,713 | 467 | 129 | 0.0 | Rose and Carlson, 1986 |
| 2:A & 1:MRE | 1985 | Temperate, Hawaii | 33 | 16 out of 44* | 3,047 | 334 | 113 | ~1.3 | USACDEC/USARIEM, 1986 |
| 2:T & 1:MRE | 1985 | Temperate, Hawaii | 33 | 16 out of 44* | 2,689 | 354 | 105 | ~1.4 | USACDEC/USARIEM, 1986 |
| 1:T & 2:MRE | 1985 | Temperate, Hawaii | 38 | 16 out of 44* | 2,715 | 335 | 107 | ~2.1 | USACDEC/USARIEM, 1986 |
| MRE VI | 1985 | Temperate, Hawaii | 167 | 2 | 2,445 | 254 | 98 | NA† | USACDEC/USARIEM, 1986 |
| MRE VI | 1986 | Temperate, Camp Ethan Allen, VT | 17 | 30 | 2,782 | 318 | 112 | 2.2 | Askew et al., 1987 |
| 2:A or B & 1:MRE VI | 1988 | Hot, Ft. Hood, TX | ?‡ | 8 | 3,056 | 404 | 113 | 1.0 | M.S. Rose et al., 1989 |
| 2:B & 1:MRE VIII | 1990 | High altitude, Bolivia | 35 | 15 | 2,140 | 244 | 97 | 2.0 | Edwards et al., 1991 |
| 2:B & 1:MRE VIII + Suppl.§ | 1990 | High altitude, Bolivia | 32 | 15 | 2,265 | 271 | 100 | 2.0 | Edwards et al., 1991 |
| MRE XII | 1991 | Temperate, Ft. Chaffee, AR | 32 | 30 | 2,901 | 358 | 125 | 4.8 | Thomas et al., unpublished‖ |

*, The Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) conducted in Hawaii in 1985, recorded food intake on days 2, 3, 6, 7, 12, 13, 18, 19, 24, 25, 30, 31, 36, 37, 42, and 43 of a 44-d field exercise; †, NA, not available; ‡, technical report did not report sample sizes of gender groups; §, the supplement group received approximately an additional 125 g of carbohydrate and 775 kcal/d in a food packet containing cookies, candies, bread and jellies, and nut-raisin mix; ‖, C. D. Thomas et al., U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data.

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1989). Mean weight losses in the Bolivia study were 2 percent of initial body weight for both the supplemented and control groups, consistent with body weight losses reported by other investigators for a 2-wk period at moderate altitude (Boyer and Blume, 1984; Fulco et al., 1985). The soldiers in this study were heavy equipment operators and not very physically active. Had they been required to perform the hard work typical of many high altitude field operations, weight losses may have been much greater.

MND's most recent ration study was a 30-d trial of the MRE conducted at Fort Chaffee, Arkansas. The control group for this study underwent the same training activities as the test group, but received two hot A Ration meals in a fixed dining facility on post and 1 MRE/d to be eaten at the worksite. The test group received 3 MREs/d. Both groups had scheduled meal times and were given ample time to eat. Flameless ration heaters were provided with the MREs. Because the MRE test group ate their breakfast and dinner rations at their bunks in the barracks, they avoided many of the situational factors that are thought to influence food consumption negatively (Hirsch and Kramer, 1993), such as they were protected from the elements, had ready access to potable water, and could wash their hands. Irregardless of this positive environmental situation, the test group consumed about 450 kcal less than the control group, and both the test and the control groups lost weight. The MRE test group lost a mean of 4.8 percent of initial body weight (9.1 lb or 4.1 kg) by day 30, while the control group lost a mean of 2.4 percent (4.3 lb or 2.0 kg).

The above studies show that soldiers typically do not consume enough rations during field operations to maintain body weight. For the most part, the longer the field study, the greater the weight loss. When more fresh foods and a greater variety of foods are offered, energy intakes are greater and weight losses are less. The presence of scheduled feeding periods, which occurs when hot foods are provided, enhances ration intakes.

### Dietary and Energy Intakes During Cold Weather Field Training

Winter conditions in arctic and subarctic areas impose many constraints on the adequate feeding of troops. Freezing affects not only the ability to open ration packages but also the palatability and acceptability of the ration. All tasks take longer in cold-weather operations, leaving less time to prepare and consume food or beverages. Table 8-5 shows the results of cold-weather ration studies. Although energy intakes were higher in the cold-weather studies than what was observed in other field studies, they did not come close to the 4,500 kcal energy allowance for cold-weather operations. Based on the MRDA,

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TABLE 8-5 Mean Dietary Intakes of Military Men during Cold-Weather Training

| Ratio | Year | Location | *N* | Study Duration (days) | Energy (kcal) | Carbohydrate (g) | Protein (g) | Weight Loss (%) | Reference |
|---|---|---|---|---|---|---|---|---|---|
| 4:MRE | 1986 | New Hampshire | 16 | 9 | 2,733 | 302 | 99 | 4.0 | Roberts et al., 1987 |
| 4:MRE III | 1988 | MMWTC* | 8 | 11 | 3,217 | 369 | 133 | 3.3 | Morgan et al., 1988 |
| 31/2:MRE VIII | 1989 | Alaska | 31 | 10 | 2,802 | NA † | NA † | 2.0 | Edwards et al., 1989 |
| MRE VIII + Suppl. | 1989 | Alaska | 34 | 10 | 3,553 | NA † | NA † | 1.7 | Edwards et al., 1989 |
| MRE VIII + Suppl. | 1990 | Alaska | 72–76 ‡ | 8 | 2,729 | 320 | 114 | 1.6 | Edwards et al., 1990 |
| RCW[§] | 1986 | New Hampshire | 18 | 9 | 2,751 | 384 | 83 | 3.0 | Roberts et al., 1987 |
| RCW | 1988 | MMWTC | 10 | 11 | 2,892 | 410 | 95 | 3.4 | Morgan et al., 1988 |
| RCW | 1988 | Alaska | 16 | 8 | 2,891 | 386 | 92 | 3.1 | Roberts et al., 1989 |
| RCW | 1990 | Alaska | 68–76 ‖ | 8 | 2,943 | 421 | 97 | 1.7 | Edwards et al., 1990 |
| 2:T[#] & 1:MRE | 1991 | Alaska | 37 | 10 | 3,271 | 375 | 134 | 1.1 | King et al., 1992 |

*, Marine Mountain Warfare Training Center, Pickel Meadows, Calif.; †, NA, not available; study mean not reported; ‡, data reported as mean of days, not mean of individuals. There were 75 or 76 usable dietary records depending on study day. Weight change data reported for 72 subjects; §, Ration, Cold Weather, ‖, data reported as mean of days, not mean of individuals. There were 69 to 76 usable dietary records depending on study day. Weight change data reported for 68 subjects; #, T Ration; see description of this ration in in Table 8-3.

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energy deficits ranged from approximately 950 to 1,770 kcal, and averaged 1,500 kcal for all studies.

The 1991 Alaska study (King et al., 1992) was the only cold-weather study that MND conducted in which hot meals were provided. Not unexpectedly, this study had one of the highest energy intakes and the least weight loss of any of the cold-weather tests.

## Dietary and Energy Intakes of Military Women

Table 8-6 presents the energy, carbohydrate, and protein intakes of military women in garrison and in the field. Energy intakes ranged from 1,832 kcal at Fort Lewis to 2,592 kcal in enlisted basic training. All of the women studied had energy intakes greater than the 1985–1986 NFCS-CSFII results for women 19 to 34 years of age, which averaged 1,558 kcal (USDA 1987, 1988). The current MRDA for women is 2,000 to 2,800 kcal.

MND has conducted only two studies in the field that included women. The first study was a hot-weather study at Fort Hood, Texas, in which the women received two hot meals and had liberal access to commercial snack foods. The women (as did the men in this study), on average, maintained body weight. The other field study was conducted at high altitude in Bolivia. Again, a depression of food intakes was seen at high altitude; however, body weight losses averaged only 0.74 percent, which indicates that energy intakes were sufficient to provide for the women's physical activity.

## Intentional Weight Loss

Some of the weight losses observed during field operations are intentional. Many soldiers use field exercises as opportunities to diet. When asked prior to a number of different studies about their desire to lose or gain weight, 12 to 86 percent of participants reported that they wanted to lose weight (Edwards et al., 1989; USACDEC/USARIEM, 1986). However, up to 26 percent of study populations expressed the desire to gain weight (King et al., 1992). Although MND usually saw a mean body weight loss in its studies, there was always a small proportion of soldiers who gained weight.

## Carbohydrate

Perhaps of more concern than the energy deficit observed during field studies is the carbohydrate deficit. Carbohydrates are very important in a

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TABLE 8-6 Dietary Intakes of Military Women

| Ration | Year | Environment and Location | *N* | Study Duration (days) | Energy (kcal) | Carbohydrate (g) | Protein (g) | Reference |
|---|---|---|---|---|---|---|---|---|
| Garrison | | | | | | | | |
| A | 1987 | Temperate, Ft. Lewis, WA | 12 | 6 | 1,832 | 212 | 75 | Szeto et al., 1987 |
| Academy/ Training | | | | | | | | |
| A | 1979 | Temperate, West Point, NY | 54 | 5 | 2,454 | 284 | 84 | Kretsch et al., 1986 |
| A | 1988 | Hot, enlisted basic training, Ft. Jackson, SC | 40 | 7 | 2,467 | 318 | 96 | R.W. Rose et al., 1989 |
| A | 1990 | Temperate, West Point, NY | 86 | 5 | 2,314 | 325 | 79 | Klicka et al., 1993 |
| A | 1993 | Temperate, enlisted basic training, Ft. Jackson, SC | 49 | 7 | 2,592 | 365 | 82 | King et al., 1994 |
| Field | | | | | | | | |
| 2:B & 1:MRE | 1988 | Hot, Ft. Hood, TX | ?* | 8 | 2,343 | 328 | 82 | M.S. Rose et al., 1989 |
| 2:B & 1:MRE | 1990 | High altitude, Bolivia | 13 | 15 | 1,668 | 218 | 68 | Edwards et al., 1991 |

* Technical report did not report sample size of gender groups.

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physically active population. Field operations typically involve repeated, short-duration, high-intensity activities that rely heavily on carbohydrate stores for energy (Saltin and Karlsson, 1971). In addition, soldiers frequently must perform extended activities of moderate intensity, such as road marches. Availability of carbohydrate fuels determines endurance during prolonged activities. Potentially contributing to carbohydrate depletion is an increased usage of muscle glycogen during exercise performed in hot environments (Fink et al., 1975), and glycogen usage is increased when individuals shiver in the cold (Jacobs et al., 1985). Muscle glycogen depletion can occur over repeated days of heavy activity (Costill et al., 1971). Failure to restore muscle and liver glycogen stores will result in fatigue and disorientation and may increase the risk of injury (Williams, 1988).

There is no MRDA for carbohydrate. Sports nutritionists recommend a diet of at least 8 g/kg of body weight per day for individuals working hard for several hours a day. This corresponds to a carbohydrate intake of 500 to 600 g or approximately 65 percent of total calories. A carbohydrate intake of 6 g/kg/d is considered sufficient for persons exercising for 1 hour or less per day. This level would equate to about 400 to 500 g of carbohydrate per day.

MND found mean carbohydrate intakes greater than 400 g in only four field studies. One of these studies was the Fort Sill study in which three hot A Ration meals were fed (mean carbohydrate intake, 467 g) (Rose and Carlson, 1986). Another study was the Fort Hood study in which two hot B Ration meals were provided (M.S. Rose et al., 1989). The other two studies were cold-weather studies in which the high-carbohydrate Ration, Cold Weather (RCW) was the sole ration provided (Edwards et al., 1990; Morgan et al., 1988). The RCW provides about 650 g of carbohydrate, while the MRE provides about 475 g of carbohydrate.

## Protein

Although energy and carbohydrate intakes are generally lower than desired, mean protein intakes almost always approach the MRDA of 100 g for men and 80 g for women (Tables 8-4, 8-5, and 8-6). The MRDA levels are probably adequate, although they are not as generous as they may seem. Energy deficits combined with increased levels of physical activity would increase the absolute protein requirement. Most of the studies that found mean protein intakes below the MRDA were conducted in the cold and involved the RCW, which was designed to contain less protein in an effort to conserve body water. Protein intakes ranged from 12 percent of calories for men consuming the RCW in the New Hampshire study (Roberts et al., 1987) to 18 percent of calories for men in the Bolivia study (Edwards et al., 1991). The women in the

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altitude study in Bolivia consumed only 68 g of protein, but protein intakes still averaged 16 percent of calories (Edwards et al., 1991).

One reason why protein intakes are relatively high is that service members, whether in garrison or eating operational rations in the field, typically consume the entree. Entrees are the major protein contributors in military rations. Because of the disproportionately greater consumption of the high-protein entrees, mean protein intakes during the MRE studies were 16 to 17 percent of calories, even thought the MRE provided only 14 to 15 percent of calories as protein (see Tables 8-4, 8-5, and 8-6).

## Micronutrients

Calcium is one of the micronutrients of concern. Figure 8-1 depicts mean calcium intakes of most of the MND study groups. The Recommended Dietary Allowance (RDA) of 1,200 mg was used for comparison because many of the study participants were 25 years of age or less (NRC, 1989). These data reveal the problem of promoting adequate calcium intake in the field. The three field-study populations that met the RDA for calcium received aseptically-packaged milk as part of their hot meal provision. None of the studies with women found a mean calcium intake meeting the RDA of 1,200 mg, although all but

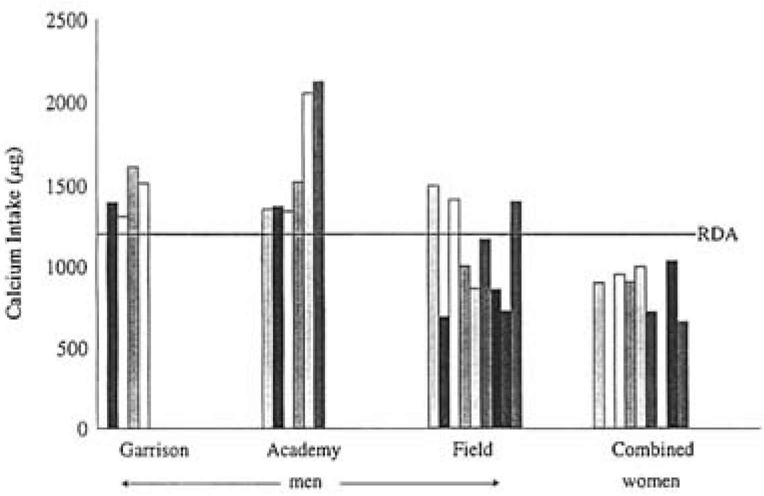


**FIGURE 8-1**
Mean calcium intakes of male and female service members compared to the Recommended Dietary Allowance (RDA) (NRC, 1989) of 1,200 mg for individuals 19 to 24 years of age.
Data were combined from several studies as listed in endnote 1.

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two studies met the MRDA for calcium of 800 mg[2]. These two studies included women in Bolivia and the recent study of women undergoing basic training at Fort Jackson.

Figure 8-2 charts the folate intakes of most of the MND study groups. Very few of the groups met the MRDA for folate of 400 µg (AR 40-25, 1985). If the 1989 reduced RDA values for folate were used for comparison, (men: 200 µg; women: 180 µg), four of seven field studies with men for which folate was analyzed would have found adequate intakes, and study means of three of the four studies with women would have met the criterion. Given that almost all female service members are of child-bearing age, the higher MRDA figure may be more appropriate. An argument often presented to counter the findings of low folate intakes is that there are too many missing values for folate in the ration data base. Data are thus also missing in the present analysis, but most of the ration items for which folate data are missing would be insignificant sources of this nutrient.

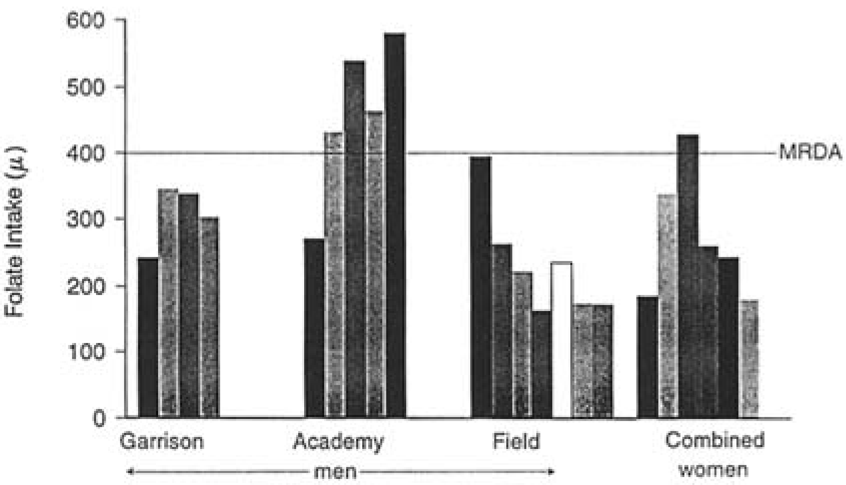


**FIGURE 8-2**
Mean folate intakes of male and female service members compared to the Military Recommended Dietary Allowance (MRDA) (AR 40-25, 1985) of 400 µg.
Data for folate were not reported due to missing food composition data.
Data were combined from several studies as follows listed in endnote 2.

[2] The MRDAs (AR 40-25, 1985) are based on the earlier ninth edition of the RDAs (NRC, 1980), and are being revised.

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Not Eating Enough: Overcoming Underconsumption of Military Operational Rations
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### Food Waste

Another way to measure underconsumption of rations is to look at food waste. When energy intakes were compared to calories provided, energy intakes were consistently 1,000 to 2,000 kcal less than issue. Table 8-7 presents nutrient consumptions as a percentage of what was provided. Mean energy intakes ranged from 47 to 78 percent of the energy provided when the ration approximated energy requirements. Only in the study in which the Ration, Lightweight (RLW) was provided as a restricted ration did ration consumption approach 100 percent (Askew et al., 1987). MND study participants tended to consume more of the protein in the ration than they did energy or carbohydrate. Eleven of the 14 study groups listed in Table 8-7 consumed a greater percentage of the protein in the ration than they did of the energy provided. This finding illustrates the disproportionate consumption of ration components, with service members favoring the high-protein entrees. Despite a significant amount of food waste, soldiers tended to rate the amount of food provided as insufficient.

One reason nutrients are not consumed is that they are not taken to the field. When soldiers were allowed to take only the ration components they wanted to the field (based on two studies that were able to document this information), they took only 3,400 to 3,600 kcal, which was about 70 percent of the ration issued (Askew et al., 1987; Roberts et al., 1987). Of this, they consumed about 2,700 kcal. These two study groups were provided 4,023 kcal and 4,892 kcal, respectively. Space in the backpack is at a premium and therefore, soldiers will not carry what they know they will not eat or what is too heavy or too bulky. This fact was reemphasized by a study conducted by Natick Research, Development and Engineering Center at Fort Chaffee, Arkansas in 1985 (Siegal et al., 1985). One test group in the study was allowed to take to the field only what they "normally would take." This "normal" group took a combination of ration components and commercial products. Unfortunately, the amount of food or ration items actually taken was not quantified; however, judging by nutrient intakes, the quantity taken was minimal. The normal group consumed a mean of only 1,028 kcal, 126 g of carbohydrate, and 41 g of protein over the 12 days of the study. They consumed 689 kcal and 855 kcal less, respectively, than the other two test groups who were intentionally provided calorically restricted rations.

### Variety

Increasing the variety of tastes, textures, or colors increases food intakes (Rolls et al., 1981, 1982). This fact was exemplified by a study conducted in

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TABLE 8-7 Proportion of Nutrient Provision Consumed (in Percent)

| Ration | Year | Location | Energy | Carbohydrate | Protein | Fat | Reference |
|---|---|---|---|---|---|---|---|
| RLW* | 1986 | Camp Ethan Allen, VT | 98 | 100 | 94 | 97 | Askew et al., 1987 |
| 2:RLW† | 1988 | MMWTC‡ | 76 | 86 | 77 | 67 | Morgan et al., 1988 |
| 2:RLW + Suppl.§ | 1989 | Mt. Rainier, WA | 47 | 47 | 51 | 41 | Jones et al., 1990 |
| 4:MRE III | 1986 | White Mountains, NH | 56 | 55 | 57 | 55 | Roberts et al., 1987 |
| MRE VI | 1986 | Camp Ethan Allen, VT | 69 | 64 | 74 | 74 | Askew et al., 1987 |
| 4:MRE VIII | 1988 | MMWTC | 62 | 57 | 69 | 67 | Morgan et al., 1988 |
| MRE VIII + Suppl. | 1989 | Alaska | 78 | 76 | 70 | 79 | Edwards et al., 1989 |
| MRE VIII + Suppl. | 1990 | Alaska | 59 | ~57 ‖ | ~59 ‖ | ~79 ‖ | Edwards et al., 1990 |
| MRE XII | 1991 | Ft. Chaffee, AR | 55 | 50 | 65 | 58 | Thomas et al., unpublished** |
| RCW †† | 1986 | White Mountains, NH | 61 | 56 | 77 | 65 | Roberts et al., 1987 |
| RCW | 1988 | MMWTC | 65 | 62 | 79 | 65 | Morgan et al., 1988 |
| RCW | 1988 | Alaska | 57 | 51 | 65 | 64 | Roberts et al., 1989 |
| RCW | 1990 | Alaska | 64 | ~64 ‖ | ~81 ‖ | ~68 ‖ | Edwards et al., 1990 |
| 2:T & 1:MRE | 1991 | Alaska | 51 | 44 | 60 | 57 | King et al., 1992 |

*, Ration, Lightweight, a completely dehydrated, restricted calorie ration, provided approximately 1,976 kcal, 194 g of carbohydrate, 68 g of protein, and 103 g of fat; †, Ration Lightweight provided 4,219 kcal, 400 g of carbohydrate, 142 g of protein, and 230 g of fat; ‡, Marine Mountain Warfare Training Center, Pickel Meadows, Calif.; §, Ration, Lightweight plus supplement provided 5,200 kcal, 700 g of carbohydrate, 142 g of protein, and 230 g of fat; ‖, macronutrient provision not quantified in report; estimated from current ration data; **, C. D. Thomas et al., U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data; ††, Ration, Cold Weather.

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Alaska in 1989 (Edwards et al., 1989). When a supplement pack containing candy, jerky, and trail mix was added to the MRE, energy intakes were higher (3,533 Kcal) than when the same number of calories (4,565 kcal) was provided by simply providing more MREs (2,802 kcal) (Figure 8-3). Not only did the supplements contribute to energy intakes, but consumption of the MRE was greater as well.

In contrast, the next year when 4,604 kcal were provided by a similar supplement pack with the MRE, energy intakes were only 2,729 kcal (Edwards et al., 1990). However during this second year, physical activities of the test unit were much lower than those of the unit studied in 1989. Based on energy intake and body weight loss, assuming that the energy deficit incurred by body weight loss is 3,500 kcal per pound, energy expenditures were 4,603 kcal and 3,954 kcal for the MRE VIII + supplement groups in 1989 and 1990, respectively. But weight losses of the two supplemented groups were comparable, 1.7 percent and 1.6 percent for the 1989 and 1990 study groups, respectively. So, although the unit studied the second year did not require as many calories and, therefore, theoretically needed to eat less and could more easily meet their needs, the weight-loss data indicate that they experienced the

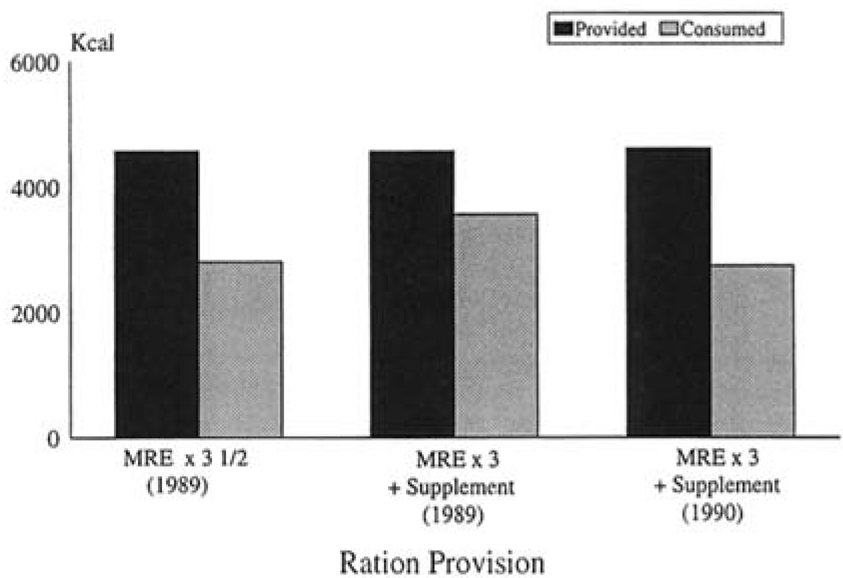


**FIGURE 8-3**
Effect of supplement pack with the Meal, Ready-to-Eat (MRE) on energy intakes during two cold-weather field studies.
Figures in parentheses are the years of the respective studies.
Three or 3 1/2 MREs (3 1/2:MRE) were provided as the ration.
Data compiled from Edwards et al. (1989, 1990).

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same energy deficit. Therefore, whereas increasing the variety of ration components should be done to enhance dietary intakes, this should not be expected to prevent weight loss.

### Energy Intakes Versus Energy Expenditures

The best way to assess energy deficit during field operations is to compare energy intakes to actual energy expenditures. MND has used the doubly labeled water method (Schoeller and van Santen, 1982) to measure energy expenditures in subsamples of study groups in six field studies. Table 8-8 presents the results of these studies.

Energy deficits ranged from 520 kcal/d, in a group that was moderately active in a temperate environment, to 2,199 kcal/d in a group conducting a difficult mountain operation under extreme winter conditions. Average energy deficit for the six studies was 1,552 kcal/d or 34 percent.

Table 8-8 Energy Intake as a Proportion of Energy Expenditure

| Year | Environment and Location | Energy Expenditure (kcal) | Energy Intake (kcal) | Difference (kcal) | Proportion (%) | Reference |
|---|---|---|---|---|---|---|
| 1986 | Temperate, Vermont | 3,480 | 2,960 | 520 | 85 | Askew et al., 1987 |
| 1988 | Cold, high altitude, California· | 4,900 | 3,132 | 1,768 | 64 | Morgan et al., 1988 |
| 1990 | Cold, Alaska | 180 | 3,060 | 2,120 | 59 | Edwards et al., 1990 |
| 1991 | Cold, Alaska | 4,250 | 3,330 | 920 | 78 | King et al., 1992 |
| 1990 | Cold, high altitude, Washington† | 4,557 | 2,358 | 2,199 | 52 | Jones et al., 1990 |
| 1990 | Cold, high altitude, Bolivia | 3,549 | 2,200 | 1,349 | 64 | Edwards et al., 1990 |

· Marine Mountain Warfare Training Center, Pickel Meadows, Calif.

† This study was not included in the rest of this paper because of small sample size and short duration. Data from Hoyt et al. (1994).

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The doubly labeled water data confirm that a significant component of the weight losses observed during field operations is due to an energy deficit and cannot be solely attributed to a fluid deficit. Although partly explainable, the energy deficits and resulting acute weight losses are of concern. Significant weight loss is almost always accompanied by loss of lean body mass as well as fat. The greater the energy deficit and the leaner the individual, the greater is the relative contribution of lean tissues to the energy deficit (Forbes, 1987). Military weight control standards insure that most service members are relatively lean. An energy deficit in excess of 1,000 kcal/d in lean individuals could lead to detrimental losses of glycogen, body water, electrolytes, and body proteins.

## CONTRIBUTING FACTORS

There is no single cause of ration underconsumption in the field, and there will be no simple solution. Most of the factors that MND has identified that contribute to underconsumption fall into one of four interrelated categories: the ration, training schedule, environment, and command emphasis.

### The Ration

Provision of at least one hot meal per day enhances nutrient intake. It does not seem to matter whether the hot meal is a T or B Ration, but there is an even greater benefit if the hot meal is an A Ration meal. When hot meals are provided, the primary reasons soldiers give for not getting enough to eat is dislike of the ration, not receiving enough food to eat, and lack of variety or boredom with the food. Taste fatigue of sweets is common. Providing more food positively affects absolute nutrient intakes, although service members seem to consume a relatively smaller proportion of the ration provided. In other words, the enhanced intakes are at the expense of greater food waste. When soldiers must carry their own food, they have to juggle competing priorities for positions in the rucksack. Food and nutrition often lose out.

### Training Schedule and Situation

When prepackaged rations are provided, the commonly cited reason for not getting enough to eat is insufficient time to prepare and eat the rations. On days when soldiers are moving their position, ration intakes are low, whereas on days that soldiers are stationary, energy intakes increase because they have

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more time and greater opportunity to heat and eat the rations. In the Fort Sill study (Rose and Carlson, 1986), it appears that intakes were high not just because A Rations were provided, but also because there were fairly regular, scheduled meal periods.

## Environment

Environmental stress adds to the physical and emotional stress of field operations or combat. There are increased energy and water requirements in hot, cold, and high-altitude environments. Furthermore, these environments may induce anorexia and an inappropriate thirst response in some individuals. Dehydration itself results in anorexia. The availability of potable water directly affects water and ration intakes, especially if ration components require rehydration before eating.

Harsh environments may also directly affect the training schedule because all tasks are more difficult and take longer to accomplish. This further erodes the time available to prepare and eat rations. In the cold, the process of eating is more bothersome because it is difficult to rehydrate or heat a ration in the cold, to get water and keep it from freezing, and to open ration packages with gloved or cold, stiff hands.

Environment also affects the quality of foods. Foods that are hot in the kitchen tent may literally be ice cold by the time they reach the squad tent. In hot weather, foods may be served at temperatures inappropriate to the type of food, for example, aseptically packaged milk served at 95¹F (35¹C). Blowing dust or sand can quickly render a meal unsuitable for consumption. Food preferences are also altered at environmental extremes. In cold weather, soldiers prefer hot foods and cocoa, while in the heat, they prefer ice tea and Kool Aid. A high-fat diet may be tolerated in the cold, but it is not well tolerated at high altitude. Preference for fat has been expressed in the Arctic while a preference for carbohydrate has been recorded at high altitude (Ward et al., 1989).

## Command Emphasis

Commanders and soldiers view the energy deficit as acceptable and unavoidable. The consequences of inadequate intakes of carbohydrate, protein, sodium, water, or other nutrients are not appreciated. Field feeding decisions are based more on personal preference and logistical considerations than on nutrition. R. M. Kark (1954, p. 193) found that, "Loss of military efficiency through inadequate nutrition is most often due to inadequate planning, catering

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or supply, and to inadequate training or indoctrination." Lack of command emphasis on the importance of ration consumption may be perceived by the troops as an indication that nutrition is not important.

## CONCLUSIONS AND RECOMMENDATIONS

The available data clearly show consistent energy and carbohydrate deficits, whether based on comparisons with dietary allowances, nutrient provisions, or energy requirements. The carbohydrate deficit is of concern, as it is more detrimental to performance. Carbohydrate stores are finite and easily depleted, whereas fat stores are relatively unlimited. Although simple energy imbalances are well tolerated for short periods, further research is needed on the effects of frequent weight cycling at the levels reported here in healthy, nonobese populations.

Although short-term vitamin or mineral deficits are well tolerated, the nutritional consequences of frequent, repeated periods of inadequate intake may not be so benign. The reduction in military populations will result in an increase in the amount of time spent in the field by the remaining troops. This effect is already being felt by some units that are in the field 40 to 50 percent of the time (Personal communication, C. Thomas, Dietitian, 55th Medical Group, Fort Bragg, N.C., 1993). The low calcium and folate intakes by female service members are also of concern; these nutrients are also often low in the diets of military women when in garrison (Klicka et al., 1993; Kretsch et al., 1984, 1986; R.W. Rose et al., 1989).

Although weight losses in the field are not inevitable, they are certainly difficult to prevent because of the myriad of contributing factors, many of which are not under the control of the individual or the commander. The goal should not be to prevent weight loss, but to prevent unacceptable levels of weight loss. Some recommendations are:

- Define what constitutes an unacceptable weight loss.
- Require unit commanders to weigh their troops immediately before and after a field operation (similar to a coach weighing the team before and after practice). This would emphasize the importance of maintaining food and water intakes in the field.
- Just as the military has been fairly successful with water discipline, they may need to consider developing some form of food discipline as well.
- Greater emphasis should be placed on the promotion of optimal carbohydrate intakes.

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- Efforts to increase the variety of ration components should target snack foods as well as entrees, since these "eat-on-the-go" foods provide most of the carbohydrates.
- Just as there are 12 or more MRE entrees, there could be 12 or more different starches and snacks. Slight variations in taste, texture, form, or color could constitute the differences (e.g., various flavors of crackers).
- The return of sweetened beverage bases to all ration menus should be investigated, as these were popular and effective sources of carbohydrate. Half of the MRE menus now contain artificially sweetened beverage-base powder.

## ENDNOTES

1. Data on calcium intakes for Figure 8-1 were combined from the following studies: *Garrison:* Szeto et al. (1987, 1988, 1989) and C. D. Thomas et al. (U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data); *Academy:* Baker-Fulco et al. (1990, 1994), Carlson et al. (1987), Klicka et al. (1993), Kretsch et al. (1986), and R. W. Rose et al. (1989); *Field:* Askew et al. (1987), Edwards et al. (1990, 1991), King et al. (1992), Morgan et al. (1988), Roberts et al. (1989), Rose and Carlson (1986), M.S. Rose et al. (1989), and C. D. Thomas et al. (U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data); *Combined Women:* Edwards et al. (1991), King et al. (1994), Klicka et al. (1993), Kretsch et al. (1986), M.S. Rose et al. (1989), R.W. Rose et al. (1989), and Szeto et al. (1987).

2. Data on folate intakes for Figure 8-2 were combined from the following studies: *Garrison:* Szeto et al. (1987, 1988, 1989) and C. D. Thomas et al. (U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data); *Academy:* Baker-Fulco et al. (1992, 1994), Carlson et al. (1987), Klicka et al. (1993), and Kretsch et al. (1986); *Field:* Edwards et al. (1990, 1991), Morgan et al. (1988), Roberts et al. (1989), Rose and Carlson (1986), M.S. Rose et al. (1989), and C. D. Thomas et al. (U.S. Army Research Institute of Environmental Medicine, Natick, Mass., unpublished data); *Combined Women:* Edwards et al. (1991), King et al. (1994), Klicka et al. (1993), Kretsch et al. (1986), M.S. Rose et al. (1989), and Szeto et al. (1987).

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AR (Army Regulation) 40-25 1985, *See* U.S. Department of the Army, the Navy, and the Air Force, 1985.

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## DISCUSSION

ROBERT NESHEIM: Thank you very much. We have time for a question.

RICHARD JANSEN: Are there any systematic weight data coming back from Operation Desert Shield and/or Desert Storm on the weight of the troops when they were deployed?

CAROL BAKER-FULCO: No, that unfortunately was not obtained. What I noticed, when soldiers anecdotally tell you how much weight they lost, is a grossly inflated amount in any situation.

PRISCILLA DOLLOFF-CRANE: We had a unit come back to Fort Lee from Somalia. Not Desert Shield and Desert Storm but Somalia. They were on a 2.5-m deployment from January to the middle of March 1993. Coincidentally, their commander had them perform PT (physical training) tests shortly before their deployment, and she had good starting weights for them. When she brought them back, we asked her to weigh them again. The weight ranges for fit troops were anywhere from a 10-to 35-lb drop in that 2.5-m period. They were not overweight to begin with, and there was no command pressure to lose weight. The commander did notice a lot of performance deficiencies during that time. There was not a scientific analysis, but the data are there to support the finding.

GILBERT LEVEILLE: Did they have a problem with diarrhea at that point?

PRISCILLA DOLLOFF-CRANE: No, not so much diarrhea. It was the environmental and psychological stress factors that were pronounced in the environment they were working in. Of course, nobody is sensitized to exactly what we said in terms of the command emphasis and the leadership issues involved. That is, it is accepted that you are going to lose some weight. The thing is that we are traditionally in 2-wk exercises so this attitude we have all developed is that weight loss is okay. Over a short period of time, we do not have compensatory measures in place for that.

HOWARD SCHUTZ: There are two points that are going to recur when we come up with questions. First, when we focus on carbohydrate, is the level required for maintenance of glycogenic performance supported by data? Do we really have data to support a relationship between performance and intake?

CAROL BAKER-FULCO: Not in soldiers, no.

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EDWARD HIRSCH: And the second point related to that. When we talk about things like folate, I was intrigued by your comment that they eat the entree and don't eat the other stuff. Have we really looked at adding whatever nutrients we are going to add to the entree rather than to the peripheral items?

**(NO ANSWER HERE TO QUESTION)**

HOWARD SCHUTZ: Was there any relationship between any of the underconsumption and any of the changes in the MRE that the previous speakers discussed? Because apparently there has been improvement over time. Have you noticed any reflection of that in the underconsumption data?

CAROL BAKER-FULCO: Almost during any study where we are comparing a new to an old ration, the new ration will fare much better, at least the first year we study it. If that becomes the control the next year, that is the poor ration. There is a big novelty factor.

STEPHEN PHINNEY: Have there been any attempts to add carbohydrate supplements to water to capitalize on your emphasis on the water discipline? If you get the caloric density of the beverage to 25 kcal/cc, 2 liters of water will give you 1,000 kcal of carbohydrate per day.

CAROL BAKER-FULCO: Not in conjunction with water discipline, but almost as an ergogenic aid, as a supplement. Special operations forces would use this more as a supplement.

ROBERT NESHEIM: In the sports world, it has become a component of success.

CAROL BAKER-FULCO: Yes. A liquid supplement seems to be much better.

ROBERT NESHEIM: I think we have to be a little careful in looking at what might be a carbohydrate requirement, for example, in terms of maintaining muscle glycogen because a soldier is not a marathon runner. The level of activity for a soldier is not as high for a prolonged period of time. Consequently, even on a lower carbohydrate intake, there is an opportunity for regeneration of muscle glycogen if they are eating. So I think we cannot make those direct translations, and we have to be very careful.

DAVID SCHNAKENBERG: I think it is not a question of whether you can maintain or restore muscle glycogen by adding carbohydrate if you have not fixed the caloric energy deficit. I mean, if you put in even 400, 500, or 600 g

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of carbohydrate, if you still have an energy deficit, you are going to have difficulty in restoring your energy.

EDWARD HIRSCH: I just wanted to ask Carol quickly about women and the number of women in your samples. Are they substantial enough?

CAROL BAKER-FULCO: I am not sure if I have the actual *N* values of the women. I can look it up and answer, but I cannot remember the *N* values now. I have been pulling this data from reports, and they are all jumbled up in my mind right now.

EDWARD HIRSCH: Because the numbers we are starting to see are five or six or seven in a group in a field study and never quite enough to know what is going on.

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# 9

# The Effects of Ration Modifications on Energy Intake, Body Weight Change, and Food Acceptance

*Edward Hirsch*[1]

## INTRODUCTION

Over the past 10 years military rations have undergone extensive testing during field training exercises (Hirsch and Kramer, 1993; see Baker-Fulco, Chapter 8 in this volume). On the basis of detailed data from these field tests as well as qualitative feedback from troops and their commanders, operational rations have been continuously modified to better meet customer and mission needs (see Darsch and Brandler, Chapter 7 in this volume). To determine whether these changes have produced genuine improvements in the rations, this overview examines changes in food intake and ration acceptance in those studies that have compared a new version of a ration to a version that has been in use for at least a year. In addition, these studies will be examined to see if there is an organizing principle that allows specification of the necessary and sufficient conditions for producing a ration that leads to an increase in food

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intake, less weight loss, and improved customer satisfaction. These studies will also be reviewed from the perspective of trying to develop a better understanding of the factors that control food intake during military exercises.

## MEAL, READY-TO-EAT

The Meal, Ready-to-Eat (MRE) was introduced as the military's operational ration in the early 1980s. Packaged in a flexible, retort pouch[2], it replaced a canned ration, the Meal, Combat Individual (MCI). Components of both rations can be eaten hot or cold and provide a nutritionally complete diet. When the MRE was introduced into the military feeding system, there was considerable interest among military planners and logisticians in having troops subsist on operational rations as their sole source of food for lengthy periods of time. For this reason the initial test of the MRE was designed to determine the consequences of prolonged feeding of this ration to troops during an extended field training exercise (Hirsch et al., 1985).

During MRE test development, the remaining stock of MCIs was being depleted, and some units were already eating the MRE in the field. Undocumented reports from these units suggested that troops consuming the MRE were experiencing gastrointestinal difficulties. These rumors, in conjunction with the possibility that food monotony (Kamen and Peryam, 1961; Schutz and Pilgrim, 1958; Siegel and Pilgrim, 1958) might develop with the MRE, led to the decision to conduct a laboratory test prior to a field evaluation (Hirsch and Kramer, 1993). The Army was concerned that a serious decline in consumption might occur when a ration with as few different components as the MRE was fed as the sole source of food for an extended time.

### Prolonged Feeding Studies

The results of two extended feeding studies where the MRE was fed as the only source of food (Hirsch and Kramer, 1993; Hirsch et al., 1985) provide both a definition of the underconsumption problem and potential insight into its solution. The laboratory study was conducted with paid student volunteers at the Massachusetts Institute of Technology over a 44-d period (Hirsch and Kramer, 1993). Volunteers took all their meals in a small, pleasant dining room. Hot and cold water was available for preparing beverages and

[2] The retort pouch consists of a laminated foil that is hermetically sealed on all four sides and can withstand thermoprocessing at 240¹ F for 30 minutes.

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rehydrating ration components. Rations could be heated in a microwave oven. The field study took place with U.S. Army troops during a 34-d field training exercise at the Pohakuloa Training Area on the island of Hawaii (Hirsch et al., 1985).

Major findings of the feeding studies are shown in Table 9-1. Under laboratory conditions student volunteers consumed 3,149 kcal/d, lost a little more than 1 lb (0.45 kg), and rated the MRE about 6.05 on a 9-point hedonic scale (Peryam and Pilgrim, 1957). They did not experience any gastrointestinal discomfort. Feeding the MRE for 44 days under laboratory conditions, therefore, did not appear to be a problem. In contrast, when the identical ration was fed to troops under field conditions for 34 days, energy intake averaged 2,189 calories, and troops lost 4.8 percent of their original body weight, despite reporting the MRE to be quite acceptable with an average hedonic rating of 7 (Fox et al., 1989; Hirsch et al., 1985; Lichton et al., 1988; Wenkam et al., 1989). Under field conditions, sole subsistence on this ration did appear to be a problem.

These data provide both the baseline condition for examining the effectiveness of subsequent ration modifications and the clear suggestion that the nature of the eating environment has a profound effect on ration intake. This latter theme is explored in detail in four other chapters in this volume (see Chapters 11, 17, 18, and 20).

In addition to highlighting potential problems with prolonged feeding of the MRE, the field test provided valuable feedback from the troops for improving the ration. Troops completed a detailed questionnaire on the nature of the changes they would like incorporated into the MRE (Hirsch et al., 1985). Many of these modifications were accomplished in later versions of the ration.

TABLE 9-1 Effects of Long-Term Feeding of MRE IV on Paid Student Volunteers and U.S. Army Field Troops

| | Duration of Feeding (d) | Energy Intake (kcal) | Body Weight Change (lbs) |
|---|---|---|---|
| Field* | 34 | 2,189 | -10.4 |
| Laboratory† | 44 | 3,149 | -1.5 |

* Field study used U.S. Army troops from Pohakuloa Training Area, Hawaii. SOURCE: Adapted from Hirsch et al. (1985).

† Laboratory study used paid student volunteers from Massachusetts Institute of Technology, Cambridge, Massachusetts. SOURCE: Adapted from Hirsch and Kramer (1993).

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### Changes in the Meal, Ready-to-Eat

Table 9-2 lists the major differences between earlier and later versions of the MREs that were tested in 1986 (Popper et al., 1987). The changes in MRE VII consisted of increases in entree portion sizes in seven menus and the inclusion of flavored beverages in all menus as well as hot sauce in three meals. The changes in MRE VIII were relatively minor compared to an experimental version of the ration called the Improved MRE. As Table 9-2 indicates, the Improved MRE retained the same structure and types of food as earlier versions, but the majority of the items in each food class was new and different.

The results of an 11-d field study where three U.S. Army companies were fed one of the versions of the MRE are shown in Table 9-3 (Popper et al., 1987). The Improved MRE group lost a significantly smaller, percentage (2.28 percent $P < 0.05$) of their initial weight than the other two ration groups, whose weight losses did not differ (2.98 percent and 3.20 percent). The group differences in weight loss were commensurate with the level of daily energy intake. Again statistical analysis revealed that the Improved MRE group consumed more calories per day than the other two groups ($P < 0.05$).

The three rations received quite different acceptability ratings from the troops. Items in the Improved MRE were rated very favorably, with no item receiving a rating below 6.0 on the 9-point hedonic scale. Many items in both

TABLE 9-2 Features of Three Versions of the MRE Tested in 1986

| Improved MRE | MRE VII | MRE I-V |
|---|---|---|
| 12 menus: 9 new and 2 reformulated entrees | 12 menus, same entrees as MRE V but 8-oz portions for 7 menus | 12 menus |
| 8-oz portions for 7 entrees | Fruit-flavored beverages in all menus | 2 beverages: coffee, cocoa |
| 2 breakfast entrees | Hot pepper sauce in 3 menus | |
| Fruit-flavored beverages in all menus | | |
| Wet pack fruits | | |
| Hot pepper sauce in 4 menus; commercial candy | | |

SOURCE: Adapted from Popper et al. (1987).

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TABLE 9-3 Average Daily Energy Intake and Percent Body Weight Loss in Three Army Companies Fed MREs

| MRE | Energy Intake (kcal) | Body Weight Loss (%) |
|---|---|---|
| Improved | 2,842 | 2.28 |
| MRE VII | 2,517 | 3.20 |
| MRE IV | 2,517 | 2.98 |

SOURCE: Adapted from Popper et al. (1987).

TABLE 9-4 Acceptance Ratings of Three Versions of the MRE by Food Class

| Food Class | Acceptance Rating Improved MRE | MRE VII | MRE IV |
|---|---|---|---|
| Entree | 7.6* | 6.8† | 5.7‡ |
| Starch | 7.4* | 7.0† | 6.0‡ |
| Spread | 7.7* | 7.4*† | 6.6‡ |
| Fruit | 8.3* | 7.5† | 6.9‡ |
| Dessert | 7.4* | 7.4*† | 6.5‡ |
| Fruit beverage | 8.3* | 8.2* | — |
| Other beverage | 8.2* | 7.5† | 7.6†‡ |
| Candy | 8.6* | 7.8† | 6.8‡ |

NOTE: Means that do not share a common superscript are significantly different at $P < 0.05$. Group comparisons are based on Student-Newman-Keuls post-hoc tests following a one-way analysis of variance where the overall $F$ indicated significant overall group differences. — = The MRE IV as tested did not include a fruit beverage. SOURCE: Adapted from Popper et al. (1987).

MRE VII and MRE IV were rated below 6.0 and in the case of MRE IV, some items were rated below 5.0, the neutral point of the scale. To compare the acceptance ratings of the three rations more formally, the average acceptance ratings for the items in each of the major food categories were computed and are shown in Table 9-4, along with results of one-way analysis of variance and post-hoc analyses, where appropriate. This table shows markedly higher ratings for the items in the Improved MRE ration compared to the other two versions of the ration. The Improved MRE was rated significantly higher than MRE IV

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across every food class, and for five of the eight food classes it was rated higher than the MRE VII.

These data make it clear that the changes incorporated into the Improved MRE produced a ration that was consumed in greater quantity, led to less weight loss, and was better liked by troops during a field training exercise. Beyond this positive outcome there are two important caveats. First, it is not known if these results would be obtained on a second or third exposure to the Improved MRE. Second, MRE VII, which incorporated some of the changes included in the Improved MRE, did not show higher levels of consumption. This finding raises the possibility that more substantial changes are required to produce an increase in ration consumption. A more precise definition of *substantial* may emerge from other studies designed to assess the effect of ration modifications.

To further improve the acceptability and consumption of the MRE, a supplement pack was developed by the U.S. Army Natick Research, Development and Engineering Center (NRDEC) that contains many of the items that soldiers most often request as additions to their rations. This supplement pack, shown in Table 9-5, was also meant to increase the total number of calories available to troops in cold weather environments where energy needs are heightened.

The MRE supplements packs were evaluated during a winter training exercise in Alaska (Edwards et al., 1989) to determine if the relatively small increase in new foods and calories was of sufficient magnitude to produce an improvement in food consumption and acceptance. One of the two supplement packs was provided to troops along with either three or four MREs per day during this test. The two different supplement packs provided a total of six new foods and either 661 or 821 additional calories.

Figure 9-1 shows that the supplement pack had large and consistent effects on energy intake in troops fed either the MRE VI or the MRE VIII. Provision

TABLE 9-5 Components of MRE Supplement Pack

| Pack 1 | Pack 2 |
|---|---|
| Pouched bread | Pouched Bread |
| Cold beverage base | Cold beverage base |
| Tabasco sauce | Tabasco sauce |
| Charms | Charms |
| Beef jerky | Nuts |
| Total kcal = 661 | Total kcal = 821 |

SOURCE: Adapted from Edwards et al. (1989).

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of the supplement pack increased MRE VI intake from 2,009 kcal to 2,830 kcal, and increased MRE VIII intake from 2,802 kcal to 3,553 kcal. Not only was the supplement eaten almost in its entirety but the supplemented groups also ate more of the MRE: 215 kcal in the case of the MRE VI group and 111 kcal for the MRE VIII group.

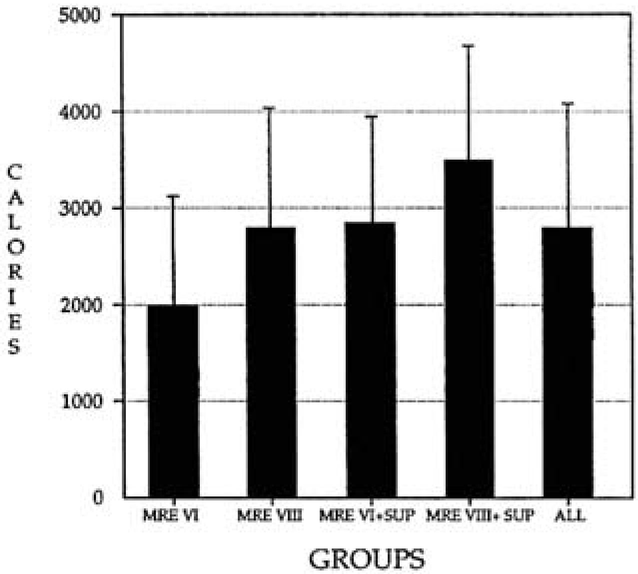


**FIGURE 9-1**
Mean daily energy intake in troops fed the SEP (Soldier Enhancement Program) MRE or MRE VIII with or without a supplement in the cold. SOURCE: Edwards et al. (1989).

The items in the supplement pack were well received by the soldiers, with average acceptance ratings in the two groups ranging from 6.67 to 8.86 on a 9-point scale. There was also an interesting effect of the supplement on acceptance ratings of the MRE components. Table 9-6 shows that the average acceptance ratings of the entrees, fruits, and desserts were elevated in the supplemented groups relative to the groups fed only the MRE. This difference was statistically reliable for the entrees in the MRE VIII groups and for the fruits in the MRE VI groups. One plausible interpretation of this observation is that new and well-liked ration components create a "halo" effect that has a positive influence on troop perceptions of the other food items in the ration.

The next series of changes in the MRE occurred as part of the Soldier Enhancement Program (SEP). Twenty-nine new items were added, including:

- six new entrees,
- five new snack items,

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- two varieties of pouch bread,
- replacement of crackers in three menus,
- nine new desserts (pound cakes, chew bars, nuts), and
- seven new beverages (shakes, tea mix, apple cider mix)

TABLE 9-6 Average Acceptance Ratings of MRE Entrees, Fruits, and Desserts for Each Ration Group

| Food Class | MRE VI | MRE VI + Suppl. | MRE VIII | MRE VIII + Suppl. |
|---|---|---|---|---|
| Entree | 6.34 | 6.73 | 7.33 | 7.97 |
| Fruit | 6.47 | 7.34 | 7.67 | 7.90 |
| Dessert | 6.10 | 6.39 | 7.32 | 7.98 |

SOURCE: Adapted from Edwards et al. (1989).

The SEP MRE certainly represented a ration that was substantially changed.

The performance of the SEP MRE was compared to MRE VIII during a 6-d field test with infantry troops at the Pohakuloa Training Area on the island of Hawaii (Lester et al., 1993). Figure 9-2 shows that energy intake was higher in the SEP MRE group, averaging 2,670 kcal/d compared to 1,956 in the MRE VIII group. Figure 9-3 shows that the higher level of intake of the SEP MRE was accompanied by higher acceptance ratings of the items in almost every

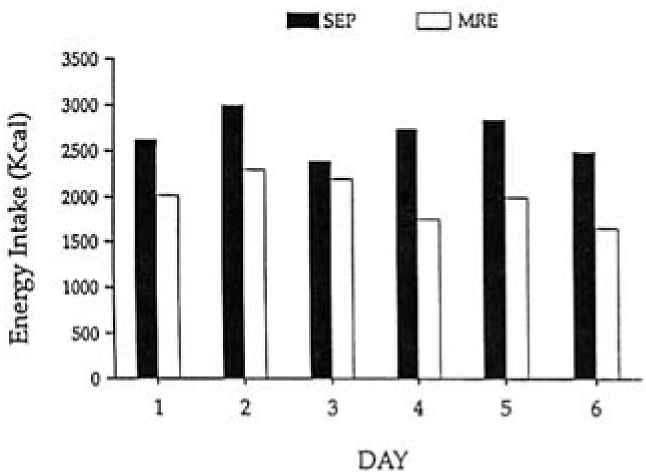


**FIGURE 9-2**
Mean daily energy intake in troops fed the SEP (Soldier Enhancement Program) MRE or MRE VIII during a field training exercise. SOURCE: Lester et al. (1993).

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food category of the ration. Once again, major changes in the composition of the MRE were associated with higher levels of food consumption and acceptance.

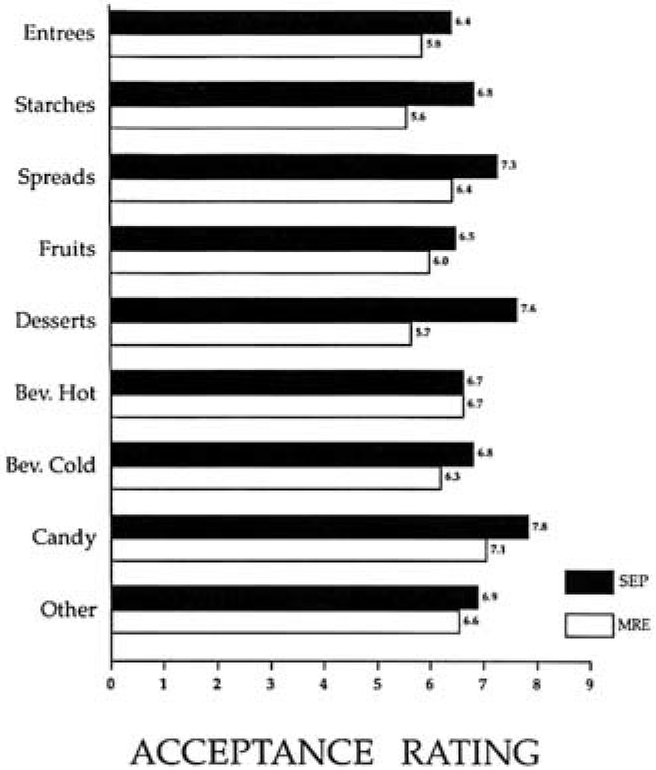


**FIGURE 9-3**
Mean acceptance ratings by food group for the SEP (Soldier Enhancement Program) MRE and MRE VIII.
SOURCE: Lester at al. (1993).

The three studies briefly reviewed showed that in every case where a revised version of the MRE was compared to an older version, it produced higher levels of food intake and customer satisfaction.

## Tray Ration

The Tray ration (T Ration) is the other major component of the U.S. Army field feeding system (see Darsch and Brandler, Chapter 7 in this volume). It is a group feeding ration where individual tray-style cans hold 12 to 18

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servings of an entree, vegetable, starch, bread, or dessert. The rectangular metal cans are half the size of a standard steam table opening and are thin enough to allow for more rapid heating than a round can, thus reducing processing time and improving quality. The T Ration is fed when time is not available to set up a kitchen and prepare hot meals from fresh components (A Ration) or from canned components (B Ration). Current feeding policy calls for two hot meals and one MRE per day if conditions permit. The T Ration serves as the hot meal in many circumstances.

A previous test (USACDEC/USARIEM, 1986) of the T Ration revealed that it is moderately acceptable to troops, and the Military Recommended Dietary Allowance (MRDA) (AR 40-25, 1985) for energy is met when this ration is provided for two meals a day along with an MRE for lunch (U.S. Department of the Army, 1985). The initial test of this ration system generated a number of recommendations for improving the ration such as:

- increase the variety of breakfast entrees by including oatmeal, other breakfast cereals, and milk;
- increase the size of dinner entrees; and
- add bread, fresh fruit, and salads to the ration.

Many of these recommendations were incorporated into revised versions of the T Ration but their effectiveness was not evaluated. Therefore, in 1990 a field test was conducted to assess these changes as well as to compare the FY1989 version of the ration to the FY1990 version (Salter et al., 1991). The two versions of the ration differed in the length of the menu cycle[3] and the substitution of new items for less popular ones. The menu cycle length of the FY1990 version had been reduced from 14 days to 10 days because of concerns that manufacturers would be unable to supply so many different menu items. Other changes to the FY1990 ration were as follows:

- Breakfast: three items dropped, one added;
- Dinner: five items dropped, two added;
- Vegetables and starches: two items dropped, one added; and
- Desserts: two items dropped, two added.

The changes in the ration had no effect on caloric intake or body weight loss during a 14-d field test. The FY1989 ration group consumed 2,888 kcal/d and lost 1.5 percent of their initial body weight, whereas the FY1990 ration group consumed 2,880 kcal/d and lost 1.0 percent of their initial body weight.

[3] The term menu cycle refers to the length of time that unique meals are served. For example, in a 10-d menu cycle, different meals are served on days one through ten, and on day eleven, the cycle begins anew.

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Similarly, differences in average food acceptance scores of the various food classes in the two versions of the ration were small (Figure 9-4). Neither ration was consistently rated higher than the other, but both tended to be rated higher than the same classes of food from the 1985 Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) (USACDEC/USARIEM, 1986). In this instance, what appeared to be substantial changes in the ration failed to improve food consumption or acceptance.

Further changes to the T Ration were implemented, and a 7-d field test was conducted to compare the FY1990 version of the ration to a newer FY1990 version that had two new breakfast and three new lunch-dinner menus containing 10 new food items (Kramer et al., 1993). In this test the group fed the old version of the ration consumed more calories and rated the various classes of food in the T Ration as more acceptable. Some of the new ration

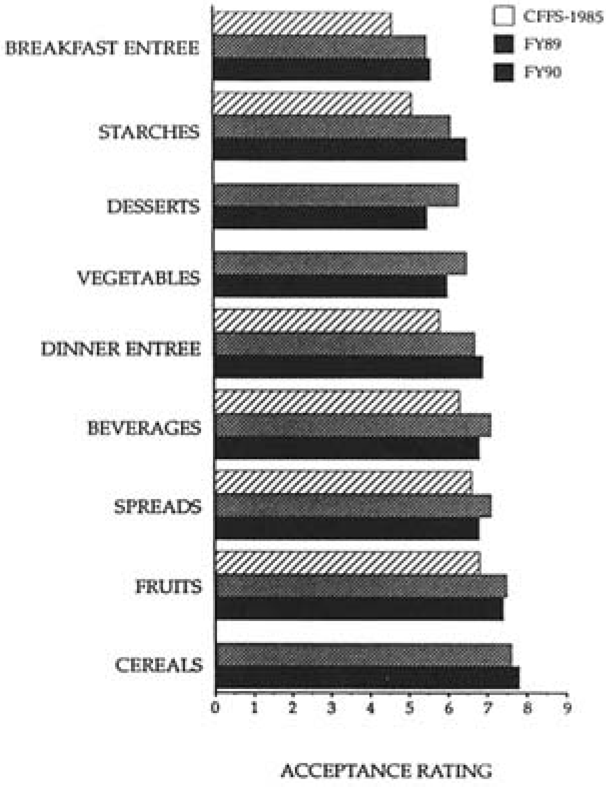


**FIGURE 9-4**
Mean acceptance ratings by food group for three versions of the Tray ration.
SOURCE: Salter et al. (1991).

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items received relatively high acceptability ratings, and others received relatively low ratings. Again it appears that the series of ration changes were not interpreted by the soldiers as overall improvements.

## CONDITIONS FOR RATION IMPROVEMENT

In an effort to define the conditions that produce genuine ration improvements, each of the studies considered previously was analyzed for the magnitude of changes in the ration, as well as the nature of any changes in food intake and ration acceptability produced by ration modifications (Table 8-7). To provide a common basis for comparing ration changes, a measure, percent change, was derived. It was defined as the number of new items in a ration that would be served during one menu cycle divided by the number of all items served during that menu cycle. Note that new items that repeat throughout the menu cycle count as new items at each repetition. For example, when hot sauce is added to three menus in MRE VII, by definition, it is counted as three new items. This measure assumes that all food items listed in the menu are available, that manufacturers have not made substitutions, and that the field distribution system actually follows the listed menu. In reality, these assumptions may be violated, but the measure provides some basis for comparison across studies.

TABLE 9-7 Effects of Ration Changes on Food Intake and Troop Acceptance

| Study | Ration | Percent Change | Energy Intake | Overall Acceptance | *x** New Items |
|---|---|---|---|---|---|
| Popper et al., 1987 | MRE VII, improved MRE | 15 | No change | Increase | 8.16 |
| | | 45 | Increase | Increase | 8.08 |
| Lester et al., 1993 | SEP* MRE | 51 | Increase | Increase | 7.33 |
| Edwards et al., 1989 | MRE VI + suppl. | 15 | Increase | Increase | 8.12 |
| | MRE VIII + suppl. | 15 | Increase | Increase | 8.43 |
| Salter et al., 1991 | FY1990 T Ration | 4.4 | No change | Increase | 6.58 |
| Kramer et al., 1993 | Revised FY1990 T Ration | 3.8 | Decrease | Decrease | 6.16 |

* SEP, Soldier Enhancement Program.

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Examining the results in Table 9-7, a general rule seems to emerge. A change in at least 15 percent of the ration items appears to be sufficient to produce an increase in calorie intake and improved consumer perception of the overall ration. The one exception concerns MRE VII (Popper et al., 1987) where the changes to the ration consisted of adding fruit-flavored beverages to all menus and hot sauce to three. In this instance, where both items repeated, the definition of ration change probably overstates the actual change. In addition, the failure of caloric beverages to increase energy intake in this study appears to be the exception (see Engell, Chapter 12 in this volume, for a complete discussion of the issue). It is clear that the definition of the magnitude of ration change needs refinement. However, it is equally clear that the vague term *substantial change* used earlier can be taken to mean approximately 15 percent.

An obvious corollary to this rule, revealed in Table 9-7, is that the new items must be acceptable to the consumer. In every case where a real improvement in the ration was demonstrated, the new items were highly acceptable. The mean acceptance ratings of the new items in the MRE studies ranged from 7.33 to 8.43. Specification of the exact parameters for ration improvement await further data, but on the basis of the current analysis, a 15 percent change in the ration, where new items are acceptable to the consumer, appears to be a good guideline for the ration developer.

It is not clear from Table 9-7 whether ration changes that led to increased food consumption and consumer acceptance resulted from replacing poorly rated food items by more acceptable ones, or whether these changes were due to increasing the amount of variety within the ration. In two of the three MRE studies described in Table 9-7 (Lester et al., 1993; Popper et al., 1987) these factors are confounded and it is impossible to separate out item replacement effects from variety effects. In the third MRE study (Edwards et al., 1989), only new items were added to the ration in the form of a supplement, and it appears that increased variety was responsible for the improvement in ration performance. The two T Ration studies listed in Table 9-7 can be regarded as item replacement studies, but they do not provide any real evidence on the issue of item replacement versus variety as the magnitude of ration change was probably too small to realistically expect changes in food consumption and overall ration acceptance.

## The Role of Variety

One interpretation of the improved consumption and consumer acceptance in the ration modification studies is that these changes resulted from increased variety in the ration system. In every instance where there was clear evidence for improvement, the changes to the ration involved greater variety. Rolls and her colleagues have convincingly demonstrated that within the context of a

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single meal, variety in the sensory attributes of food enhances intake (see Rolls [1986] for a recent review). Increases in food intake as large as 60 percent were produced by providing a four-course meal where the sensory attributes of each course varied widely (Rolls et al., 1984). More subtle sensory changes, such as variations in the shape of pasta, are capable of eliciting a 15 percent increase in food consumption (Rolls et al., 1982). These short-term changes in food intake have been convincingly linked to a reduction in the pleasantness of a food as it is consumed, and this phenomenon has been termed *sensory-specific satiety* (Rolls, 1986).

Despite the compelling nature of the data that link variety in a meal to enhanced food intake, there is little direct evidence that increased food variety over longer periods of time promotes increased food intake. As evidence for the role of food variety in promoting higher consumption, Rolls (1986) cites studies where overeating and weight gain were observed in both normal-weight and obese individuals provided with plentiful quantities of a varied and palatable diet (Porikos et al., 1977, 1982). Booth (1988) has suggested that the overeating seen in these studies resulted from the requirement that participants consume a minimum of two soft drinks per day and that these between-meal snacks are not compensated for by appropriate reductions in food intake at other meals.

Studies of rats provide other evidence for the effect of increased variety on food intake. Increased food intake and obesity were observed when rats were given free access to a variety of palatable foods (Rolls et al., 1980; Sclafani and Springer, 1976). However, these studies have not completely disentangled the effects of variety, palatability, and dietary composition on food intake and body weight gain. Moreover, the role of variety per se in producing overeating remains problematic (Sclafani, 1989).

The effects of reduced variety on long-term human food intake are more definitive. At the extreme, a monotonous liquid diet was provided as the sole source of food (Cabanac and Rabe, 1976; Hashim and Van Itallie, 1965). This regimen led to a reduction in calorie intake and weight loss in both obese and normal-weight individuals. A somewhat more varied diet, comprising military ration items, was tested under both field and laboratory conditions for periods ranging from 3 days to 5 weeks (Kamen and Peryam, 1961; Schutz and Pilgrim, 1958; Siegel and Pilgrim, 1958). A common finding in these studies was that food acceptability and consumption tended to decline over time, and the most palatable food items declined the least in acceptability. In addition, those items that are staples of the diet, such as milk, bread, and cereals, did not decline in acceptability at all. Moreover, giving individuals the opportunity to plan or self-select their menu reduced dissatisfaction with the repetitive diet (Kamen and Peryam, 1961). Interestingly, the field study of food monotony used a 4-d menu cycle with 41 foods. This menu cycle is identical to current versions of the MRE, although the number of foods is slightly higher in more recent versions of the ration. These data clearly reveal that limited variety can

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lead to reduced acceptance and consumption, but the effect of increased variety in a long-term feeding environment remains to be demonstrated.

## CONCLUSIONS

The studies reviewed indicate that a ration change that substitutes highly acceptable new food items for approximately 15 percent of the items in the old version will lead to higher levels of food consumption and consumer satisfaction. It is not possible on the basis of available evidence to specify whether this effect is due to the provision of new, highly palatable foods or the increased food variety within the ration.

A second question the available data do not address directly is whether the positive improvements in food intake and acceptance would persist on a second or third exposure to a revised ration. Many military units spend several months a year in the field eating operational rations during training exercises. Looking at the performance of a particular ration over time suggests that food monotony will occur in this setting (see Kramer, Chapter 17 in this volume). However, whether a broader range of foods and menus would produce a sufficiently varied ration to prevent food monotony after many exposures to a ration system is not known. The Sustainability Directorate, NRDEC is hoping to answer this question with 18 proposed menus in the new MRE. However there are no empirical data to guide the ration developer in knowing what constitutes sufficient variety in a feeding system. Data that addresses this issue are critical for proper ration design and success in long-term field feeding of military troops.

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## DISCUSSION

EILEEN THOMPSON: When you compared the percentages of all the individual food items for the people in the field versus the control group, were the rank orders of the items the same, or were different items preferred in the field condition?

EDWARD HIRSCH: I am trying to remember that correlation. You know it was on the order of 0.4, 0.5. There were slight differences in the ranking.

JOHN VANDERVEEN: Have you looked at if you take a comparable amount of real food or regular food versus the same sorts of things in the MRE, are you getting the same absorption?

EDWARD HIRSCH: No, that was not done. But I think maybe I misstated it or you misunderstood me. The control group consumed about 3,250 calories per day at MIT. So they were slightly in excess of need. The MRE group was slightly below requirement as defined by the 1 1/2-pound weight loss.

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JOHN VANDERVEEN: The difference was 100 calories a day which does not account for 2 1/2 pounds of weight.

JOHN DE CASTRO: When we asked people to rate the foods they self-select within their own diets, on a seven-point scale, they are between six and seven for every item. These are neutral and, in comparison to what people select in their own diets, very low ratings. But if you look at it in terms of what people will rate the foods they normally take in, those are pretty low.

EDWARD HIRSCH: Well, your population uses rating scales very differently from our population.

BARBARA ROLLS: In the student study as well, you commented that you studied them over a school term and that you tested them while they were having exams. I think stress is key here. Did intake vary when they were under more stressful circumstances?

EDWARD HIRSCH: The pattern of intake was a slight decline over time.

BARBARA ROLLS: You did not look specifically at when the exams were?

EDWARD HIRSCH: They were all on different schedules. We knew within which block of time it was. It was toward the end of the study when intake was down, so it's confounded with time on the ration.

BARBARA ROLLS: There is some literature that says that exam stress increases food intake.

JOHN VANDERVEEN: Did you ever reintroduce a food item you took out several years ago and see whether it again had an impact on rating? Is it a novel situation? If the product was reasonably good initially, it would possibly do pretty well.

EDWARD HIRSCH: I agree with you. No, we have not done that, but I think it could be done.

HOWARD MOSKOWITZ: There may be another way of looking at this data. Instead of looking at it as an item by item analysis, field versus lab, try to do a content analysis of what is present in these foods in terms of textural characteristics and other characteristics such as appearance, size, and ease of chewing. Then see whether there are any relationships that exist in the field and in the laboratory, and do those relationships differ? That is to say, are the respondents or the soldiers paying differential attention to some aspects in one venue and different aspects in another?

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EDWARD HIRSCH: Our interest in the acceptability ratings was really focused on trying to understand the consumption, not trying to explain the difference in acceptability ratings.

HOWARD MOSKOWITZ: But that is the same thing. What I am saying is you can do the same paradigm to look at consumption. Look at foods as combinations of features and test when the features change.

ROBERT SMITH: What is more important, you can use that as a model to build on.

HOWARD SCHUTZ: Did you ever look at the data in terms of individuals, and whether or not you would learn something about the differences in distribution that exist? There is a possibility that distribution may not be such that you are getting all the information out by using essentially a mean number.

EDWARD HIRSCH: Yes, we did look at a lot of individual data. For example, the weight loss ranged from zero to a couple of people exceeding 10 percent. I do not have that distribution with me, but we did try and pull that out with both the consumption and the acceptability data.

HOWARD SCHUTZ: Could you please explain a bit more about how the studies were done with regard to the novelty of the ration component? Were the same soldiers studied twice?

EDWARD HIRSCH: Well, in all the studies, you are comparing a novel item or a re-ration to an old version. The troops have seen the old version, they have been in the field before, so when you introduce the novel item or the new ration, it is a novel item for all of them. The way these studies are done, we try to find a unit that is willing to tolerate these crazy psychologists coming out and tagging around and hooking up with them once a day to take these measures. And to get a repeat sample on the same unit with the same individuals in it would be virtually impossible.

JOËL GRINKER: One problem I always had trouble dealing with was the acceptability ratings. Because the way they are used, data are collected on individual items consumed. So the individual who did not consume a particular item, that item does not get a zero in here. So you are trying to relate acceptability to consumption, but the consumption includes everything they did and did not eat, whereas acceptability ratings only reflect the items they actually did eat. I think with that type of a paradigm, you will never have a relationship of acceptability ratings to actual consumption. An alternative needs to be pursued, perhaps one that deals with characteristics of the food items. I

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do not have the answer of how to do it, but I think the current system is not good, and maybe the hedonic scale was designed for another purpose rather than to predict actual consumption.

STEPHEN PHINNEY: Was there a high level of rejection of some items?

EDWARD HIRSCH: Oh yes. Troops are only eating two-thirds of the items offered. One-third of the items are not consumed. Generally after the troop has an exposure to an item, they will either eat it all or none of it. So one-third of the calories are not even being opened.

ALLISON YATES: So they are not being rated.

EDWARD HIRSCH: The only place you will see it is on a final questionnaire where we asked people about the ration. Then even if they have not been consuming the item consistently through the field test, they will rate it. And interestingly enough, final questionnaire ratings are about a scale unit below field ratings. So you do get those people showing up and getting their two cents in.

RICHARD JANSEN: How much did the study conditions affect the outcome when you compare the MIT experiment versus the field? There is a tremendous amount of indoctrination of the subjects in some studies that "thou shall," and so maybe that is a factor in terms of getting the students to take their responses seriously also, because they were paid to do this research. Were the Army troops paid to participate in the project?

EDWARD HIRSCH: As a matter of fact, receiving their rations is part of their pay. But I think your point is well taken. I think what that says is we have to understand the situation, whether it is the variables you are pointing to or the very nature of the eating environment. It was clean, there were knives, forks, plates, water, and microwave. Eating was easy, pleasant, and if you will, permissive. Whereas in the field, it was none of those things.

ALLISON YATES: Did you do any acceptability testing with basic trainees as part of the intake studies reported by Carol Baker-Fulco because they probably did not have any former association with the foods?

EDWARD HIRSCH: I think the data Cory Baker-Fulco was referring to was in garrison where they are getting freshly prepared food as opposed to operational rations.

PRISCILLA DOLLOFF-CRANE: I thought I remembered this morning where you made a comparison between garrison and in field feeding and getting the

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same basic results. In other words, consumption in the garrison was much better than in the field, and the hedonic ratings also were less. There was the same dichotomy in the rating. In other words, it eliminates the students as a variable in the MIT study and goes back to an earlier point that it was the context that was more important than the students.

## GENERAL DISCUSSION

ROBERT NESHEIM: Thank you, Ed. What I would like to do is we have about another five minutes or so, if there are questions on the other presentations that we had this morning, we can take those at this point because we're ready to leave this sort of background information and start moving now into some discussion of the factors which might underline food intake and underconsumption of food. So are there any questions for the speakers that spoke earlier today?

GILBERT LEVEILLE: A couple of comments. One, somebody and I don't remember who, talked about troops coming back from Somalia, and while it wasn't a formal research study, they said PT tests were done. I think the Army PT tests are pretty well supervised. If this is the case, they measured body weights and performance. The troops went to the field and back. Then the tests were repeated. These data might be very helpful, because this is an experiment in actual field conditions.

RICHARD ATKINSON: I think the other piece on this is we've got new units that are deploying into a much more intense environment right now because they were there during the less stressful period of time. A lot of psychological strain in terms of the population they were assisting, but not on the same level of physical stress that the newly deployed folks are. And I think it's an opportunity staring us in the face in terms of being able to do assessments —to do a natural study collecting, starting and ending data without intruding the experimental force in terms of the mechanics of the day to day. Because one of the other things that happens when we do the two week field test assessment is that the intrusion of the measuring tool definitely has an impact. It's just like mom saying, "Are you eating your vegetables or not? Well yes, I am." As soon as you start to ask questions in terms of what are you eating, folks themselves become more aware of their own patterns and probably revert to many lessons that they've learned in other environments where there's not going to be exactly the same information if you were able to do a non-intrusive evaluation. But I think if you can obtain starting and ending weights for troops that are deployed into these very hostile environments, also collect what it is that they eat and ask them to tell you why, then you will be able to get a good set of basic information.

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STEPHEN PHINNEY: Yes, and in fact that was the other point I was going to make. We've heard several reasons why we can't compare MIT students and people in the field. But I think for some of the reasons you have just said, I don't think we can compare people in the field either to what is reality. We just heard this morning that people use this as an opportunity to lose weight. That Hawaii study was done at the height of the Army weight reduction program focus and attention. I think all of these studies have to be looked at very carefully.

I think Wayne made a very good point this morning when he said, "Does it make any difference?" To address this point I thought I heard you say that there were dramatic decreases in performance on the PT test when they came back. Is this true?

DAVID SCHNAKENBERG: We've got to be careful about this. She didn't test them as they came back in terms of the PT test itself. She did do a weight assessment, but her comment to me is that towards the end of their deployment, in the last few weeks that they were out there, she saw more sloppy work, she saw a greater accident level, she just saw people with diminished performance levels. We are not talking gross motor skills, we're talking fine motor skills. I don't think any of the studies have really one a good job in terms of assessing fine motor skills that the technological soldier needs to have available to him if he's doing his job. Can we run the hills, carry the weapons? Yes, we can for an extended period of time. But can we perform at the levels that we need to and be aware of assessing the information that's in our environment and not making mistakes such as that led to that Ranger raid that was a disaster? What kind of stresses? It would be great if we could get the data, but we will never get that. However, those finer assessments are the ones that are really critical in terms of the diminished performance after a 10 or 15 pound weight loss.

KARL FRIEDL: Yes, that data would obviously be much harder to obtain, but just doing a PT test, you know what units are scheduled to go over there—do a PT test before and immediately when they get back. That's pretty simple. If you see a deterioration, then that's a critical point.

EILEEN THOMPSON: Well, I've got to back off on that. You can, but also normally when we're in our normal day-to-day environment, we know when we're going to take a PT test. And about a month, month and a half out from that date, we're going to start going home and doing our sit-ups and our push-ups and maybe spend a little bit more time at the track so that we initiate a self improvement program simply because we know we're going to be tested. To take a population of folks that had that lead-up time to get ready for the PT test, do it and then take them out of the field environment and basically on a surprise basis or a non-optional—you never had the time, you never had the

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opportunity to do your rehearsals, you have distorted the start points. So you are going to see a diminishment anyway. I mean that's automatic. So maybe the question is you can either give a unit a surprise PT test, a non-scheduled PT test, get that information and then pull them out of these things, allow them proper sleep, because that's one thing about a returning unit is that normally the sleep deprivation is really severe, give them a day or two of returning to normal sleep patterns, and then pop a test on them at that point, I would feel much more comfortable about that information.

ROBERT NESHEIM: Thank you. I think we should move on to talking now about some of the factors that underlie food intake and underconsumption and we will get into hopefully some things that might explain some of the issues that have been—or at least raise other questions about some of the things that have come up in the previous studies here.

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# Part III

# Factors Underlying Food Intake and Underconsumption—Food

IN PART III THE ATTRIBUTES of food that affect selection, consumption, and acceptability are considered. Chapter 10 explores ration image and stereotype that find military food to be less flavorful, less appetizing, and having less variety than commercial food. This negative image translates into lowered acceptance and, therefore, lowered consumption. The author observes that by conducting an analysis to identify the informational variables (e.g., labeling and packaging) that contribute to the negative, stereotypical image of rations, it may be possible to develop a program to improve the image of military operational rations.

With research related to acceptability and consumption, Chapter 11 discusses how meal and food composition and presentation influence intake and satiety. In order to delay decreased intake upon repeated consumption, the initial palatability of a ration should be high, which may be helped by self-selection. Palatability also may be maintained with variety in flavor, texture, and appearance.

Fluid intake and its effect on energy intake and hydration are the subjects of Chapter 12. As part of the Meal, Ready-to-Eat package, research shows that beverage products account for close to 20 percent of energy intake. More beverage calories are consumed with an increased number of beverages offered and an increased accessibility to the beverages. The role of hydration in maintaining food intake as well as the potential role of beverages for supplying additional energy are mentioned.

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The section concludes with an industry perspective on increasing product acceptability in Chapter 13. The author notes that an individual's food intake behavior changes slowly, but change in food preferences and selection patterns have been demonstrated with improvements to packaging and seasoning. The author also mentions that the value of snack food as a source of additional nutrients and energy should not be overlooked.

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# 10

# The Role of Image, Stereotypes, and Expectations on the Acceptance and Consumption of Rations

*Armand V. Cardello*[1]

## INTRODUCTION

Underconsumption of military field rations is a well-documented problem, owing greatly to research undertaken during the past 5 years (see Meiselman and Hirsch, Chapters 3 and 9, in this volume). However, the cause of ration underconsumption is less clear, although it is likely to be due to multiple factors rather than to any single one. Analysis of the factors that control the consumption or underconsumption of food has identified three broad categories of variables that may contribute to the problem. These variables are (1) the food, (2) the situation in which the food is consumed, and (3) the individual who is consuming it. In the latter case, contributing variables include physiological as well as cognitive, perceptual, and attitudinal factors that affect both the perception of and the preference for various foods.

[1] Armand V. Cardello, Consumer Research Branch, Behavioral Sciences Division, Science and Technology Directorate, U.S. Army Natick Research, Development and Engineering Center, Natick, MA 01760-5020

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For military food, situational factors related to the conditions under which the food is eaten are, undoubtedly, important. Equally important for military food is the image of the food, as reflected in the attitudes of the individual toward it, his/her expectations for it, and the degree to which the food actually meets those expectations. As shall be shown, each of these variables can be a prepotent factor controlling the acceptability of food its consumption or underconsumption.

## RATION IMAGE AND STEREOTYPE

### General Public and Media Image

If one were to ask the average person about his or her image of military rations, their response would undoubtedly be a negative one. In fact, a negative image of military rations is widely held among the general public, in spite of the fact that many scientists who are actively engaged in research on military rations —product developers, consumer psychologists, nutritionists, etc. know that the intrinsic quality of rations is quite high. Although the origins of the stereotypical image of rations may be obscure, it is certainly perpetuated by the mass media. Figure 10-1 shows what are perhaps the best examples of this stereotypical image of rations—Beetle Bailey cartoons. Even a casual examination of these cartoons reveals that they impugn all aspects of military rations, including their texture (top panels), their general acceptability (middle panels), and their ingredients and/or nutritional quality (bottom panels).

What is surprising about the cartoons in Figure 10-1 is that they were all taken from the *Army Times,* the weekly military newspaper read by millions of enlisted soldiers worldwide. Thus, U.S. soldiers are constantly exposed to negative images of rations, even from promilitary media sources. As a result, one of the first issues that must be addressed to better understand the problem of underconsumption of rations is the image of military food as held by its primary consumer group—U.S. soldiers.

### Image of Rations Among Military

Figures 10-2 and 10-3, from A. V. Cardello and R. Bell (U.S. Army Natick Research Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995), show data collected from approximately 100 active-duty troops stationed at Fort Devens, Massachusetts, and at Schofield Barracks, Hawaii. Troops were asked, on a written questionnaire, to rate the expected acceptability (Figure 10-2) and the expected quality (Figure 10-3) of 12 different foods when served in each of 7 different military and commercial foodservice facilities.

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**FIGURE 10-1**
Selected Beetle Bailey cartoons from the *Army Times.*
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There are three noteworthy aspects to these data. First, the overall patterns of the data are very similar between the two groups. In fact, for the 12 food items there are few statistically significant group effects or group × foodservice interaction effects. Second, for both groups, analyses of variance (ANOVAs) with Newman-Keuls post-hoc tests ($P < 0.05$) showed the mean expected acceptability of foods eaten at home to be significantly higher than that for all other foods. Similarly, for the vast majority of the food items, those obtained at a family restaurant, diner/fast food restaurant, and school cafeteria were rated significantly higher than those from the remaining three foodservice operations. As can be seen in the data, ratings of the expected acceptability of military food were low and not significantly different from those for airline and hospital food. The 12 test foods used in the questionnaire were chosen to represent a range of items that differed in the degree of quality among the foodservice facilities. Some foods, such as steak, burgers, and french fries, could be expected to vary greatly in quality among the different foodservices.

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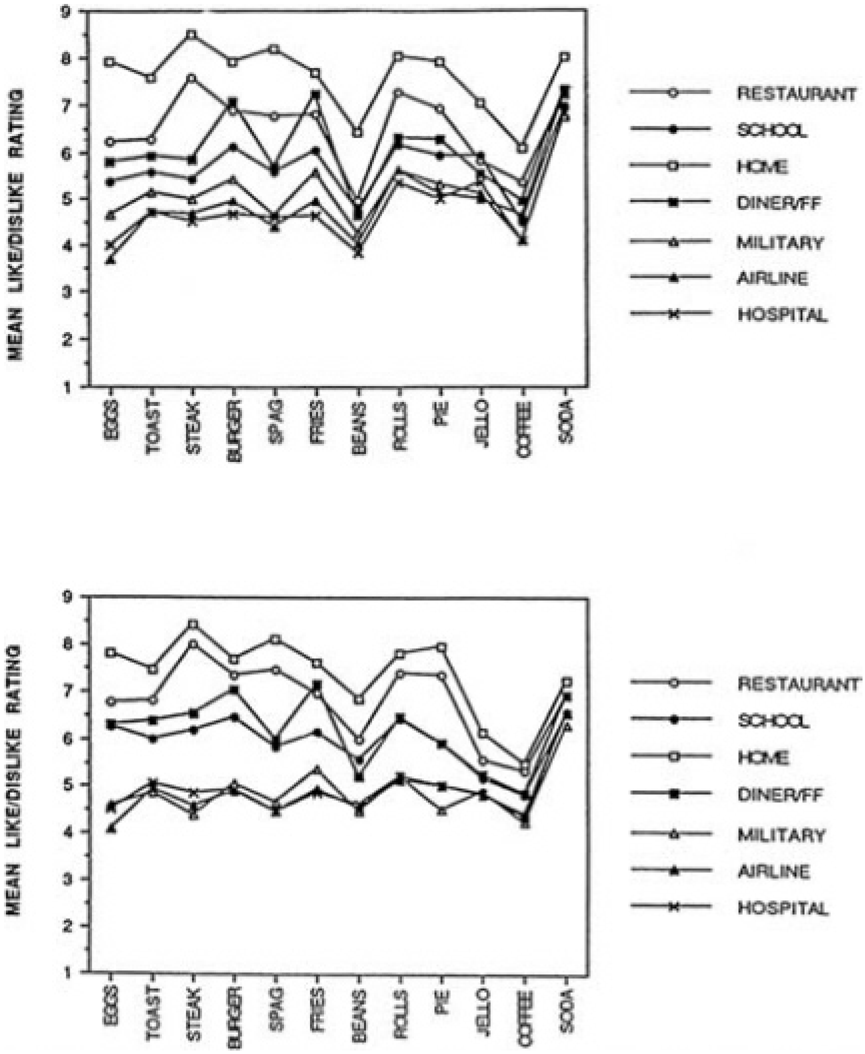


**FIGURE 10-2**

Mean expected acceptability ratings for 12 food items as served in 7 different foodservice operations. Data are from two groups of military subjects: *top*, stationed at Fort Devens, Mass. and, *bottom*, stationed at Schofield Barracks, Hawaii, FF, fast food; SPAG, spaghetti.

SOURCE: A. V. Cardello and R. Bell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995).

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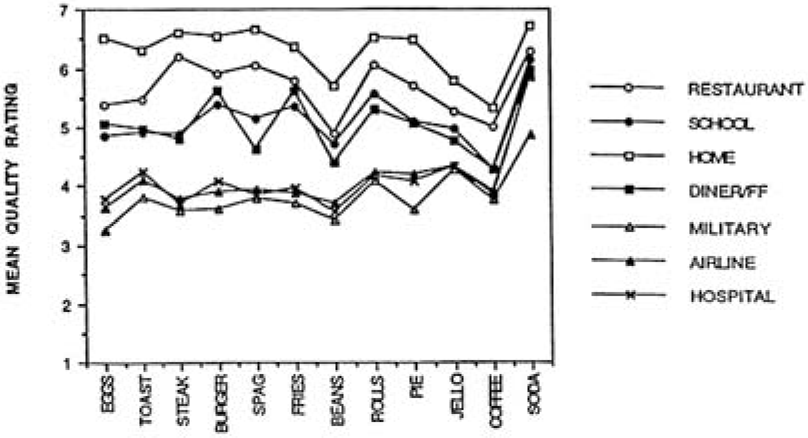


**FIGURE 10-3**
Mean expected quality for 12 food items as served in 7 different foodservice operations. Data are from military subjects stationed at Schofield Barracks, Hawaii. FF, fast food; SPAG, spaghetti. SOURCE: A. V. Cardello and R. Bell (U.S. Army Natick, Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995)

Others, such as Jell-O and soda, were foods in which great differences in quality would not be expected. Yet, even for the latter items, although the statistical variability among foodservices was smaller, the relative order of expected liking across foodservices remained the same, a fact which suggests that the effect seen in these data is a robust one.

Turning to the judgments of expected quality of the food, Figure 10-3 shows the ratings of expected quality for the troops stationed at Schofield Barracks in Hawaii. The ratings of expected quality are similar to those for expected acceptability in this group of subjects (Figure 10-2, bottom). In fact, expected acceptability and quality ratings were highly correlated (Pearson *r's* = .92 and .94) for both subject groups, as well as for those subjects whose data are shown in Figure 10-4, discussed below. This strong association is a reflection of the fact that, to most consumers, the concept of food quality is highly correlated with the hedonic value of the food.

Since the subjects in this study were consumers of military food, it is not clear whether the data in Figures 10-2 and 10-3 are a reflection of a stereotypical image of these foods or if they are a reflection of reality. To address this question, an age-matched sample of students at the University of Massachusetts at Amherst, none of whom had ever eaten military food, was administered the same questionnaire. Figure 10-4 shows the ratings for both expected acceptability and expected quality among this group of subjects. As can be seen, the data for military food are almost identical to those depicted in

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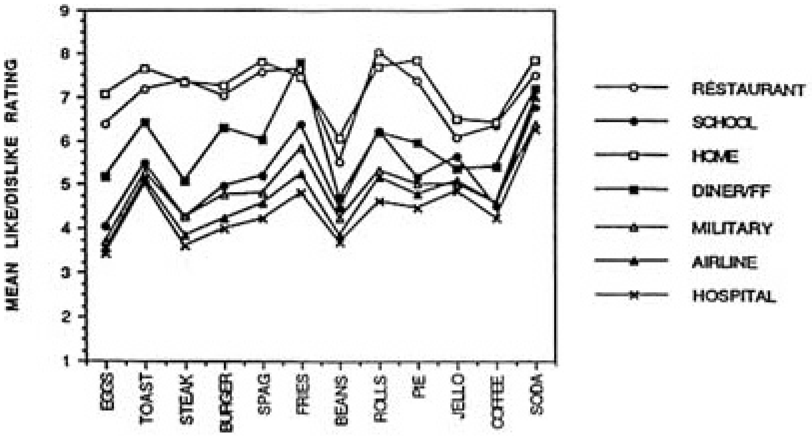


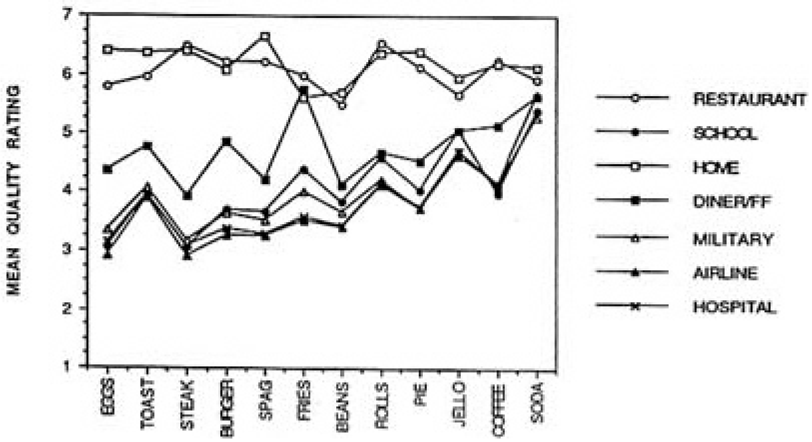


**FIGURE 10-4**

Mean expected acceptability (*top* and mean expected quality (*bottom* ) for 12 food items as served in 7 different foodservice operations. Data are from students at the University of Massachusetts, Amherst, none of whom had ever eaten military food. FF, fast food; SPAG, spaghetti. Source: A. V. Cardello and R. Bell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995).

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Figures 10-2 and 10-3 for military subjects. The fact that the civilian subjects had never eaten military food suggests that the data reflect a common stereotype in the population that is not affected by exposure to the food. In fact, ANOVAs conducted on the data from the military subjects in Figures 10-2 and 10-3 showed no effect of their length of service on ratings of expected acceptability or expected quality.

The results reported above are supported by data from other recent studies. Salter et al. (1990) studied Navy personnel, evaluating their liking or disliking for 20 foods normally served in Navy dining halls versus commercial cafeterias or restaurants. As shown in Table 10-1, subjects rated the acceptability of every tested food item to be significantly higher in commercial foodservice establishments than in Navy dining halls. In addition, this negative opinion of food items in Navy dining halls extended to other aspects of the foodservice situation (Table 10-2). In almost every case, Navy foodservice scored significantly lower on such factors as cleanliness, portion size, and even the ambient temperature of the dining hall.

## Characteristics of the Image and its Origins

If one accepts that the image of military food is a poor one, the next question to be asked is why the food is perceived to be inferior. Figure 10-5 are data from A. V. Cardello and R. Bell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995). In this study, 225 military and 195 civilian subjects were asked to rate military food as compared to commercial food on five different attributes of the food: (1) perceived nutrition, (2) flavor, (3) variety, (4) appetizing quality, and (5) degree of processing. Attributes were each rated on a 5-point scale where 1 corresponds to "less than commercial" and 5 corresponds to "much more than commercial." As shown in Figure 10-5, neither subject group perceived a difference between military and commercial food in terms of the nutrition or the degree of processing of the food. However, for both groups of subjects, military food was rated significantly less flavorful (military: [$F\{1\} = 4.38$, $P = 0.02$]; civilians: [$F\{1\} = 8.17$, $P < 0.001$]); less appetizing (military: [$F\{1\} = 4.72$, $P = 0.015$]; civilians: [$F\{1\} = 9.54$, $P < 0.001$); and having less variety (military: [$F\{1\} = 8.61$, $P < 0.001$]; civilians: [$F\{1\} = 7.09$, $P < 0.001$]) than commercial food. It is noteworthy that each of the attributes for which military food scored significantly lower relates directly to the hedonic characteristic of the food.

When asked to report the sources of information from which their opinion of military food evolved, civilian subjects in the above study identified television shows and movies, especially those seen during elementary and high school years, as critical sources of information contributing to their current

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TABLE 10-1 Mean Acceptability Ratings* of Navy Personnel for 19 Different Food Items When Served in either Navy Dining Halls or Commercial Foodservice Establishments

| Food Item | Dining Hall | Commercial |
|---|---|---|
| Chicken noodle soup | 6.1 | 7.0† |
| French onion soup | 4.0 | 5.7† |
| Meat loaf | 5.2 | 6.3† |
| Macaroni and cheese | 5.1 | 6.6† |
| Pizza | 6.0 | 7.9† |
| Spaghetti with meat sauce | 6.0 | 7.5† |
| Fried chicken | 5.8 | 7.3† |
| Cheeseburger | 6.1 | 7.5† |
| Hamburger | 5.9 | 7.4† |
| Grilled ham & cheese sandwich | 6.1 | 6.9† |
| Rice | 5.2 | 6.4† |
| Mashed potatoes | 5.6 | 6.8† |
| French fries | 6.3 | 7.5† |
| Sweet potatoes | 5.1 | 6.0† |
| Carrots | 5.3 | 6.1† |
| Green beans | 5.6 | 6.5† |
| Spinach | 4.9 | 5.8† |
| Green peas | 5.3 | 6.2† |
| Chocolate cake | 6.1 | 7.3 |
| Overall average: | 5.7 | 6.9† |

* Ratings are based on a 9-point scale, in which 1 corresponds to "dislike extremely," 5 corresponds to "neither like nor dislike," and 9 corresponds to "like extremely."

† $P < 0.001$.

SOURCE: Salter et al. (1990).

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image of military rations. In contrast, military subjects reported that information and/or exposure to military food during their basic training or during their first military assignment were the critical factors contributing to their current image of rations.

TABLE 10-2 Mean Satisfaction Ratings· of Navy Personnel for 16 Different Aspects of Foodservice in Navy Dining Halls versus Commercial Foodservice Establishments

| Item | Dining Hall | Commercial |
|---|---|---|
| Noise level | 4.1 | 5.3† |
| Cleanliness | 4.9 | 5.5† |
| Number of items per meal | 4.3 | 5.7† |
| Waiting line | 3.2 | 5.5† |
| Preparation of food | 4.0 | 5.4† |
| Nutritional quality | 4.5 | 5.6† |
| Portion size | 3.9 | 5.3† |
| Taste of food | 4.1 | 5.3† |
| Appearance of food | 4.3 | 5.8† |
| Dining hall staff | 4.5 | 5.5† |
| Hours of operation | 4.9 | 5.6† |
| Appearance of dining areas | 4.9 | 5.7† |
| Lighting | 5.3 | 5.6† |
| Temperature of dining areas | 4.6 | 5.6† |
| Air quality (smoke) | 5.2 | 5.2 |
| Number of available seats | 4.3 | 5.5† |
| Overall average: | 4.4 | 5.5† |

· Ratings are based on a 7-point scale, in which I corresponds to "extremely dissatisfied," 4 corresponds to "neither satisfied nor dissatisfied," and 7 corresponds to "extremely satisfied."
† $P < 0.001$
SOURCE: Salter et al. (1990).

Taken together, the above studies support the notion of a strong negative image of military food among both military and civilian populations. Moreover, this negative image appears to be stereotypical, since it is the same among military personnel and individuals who have never consumed military rations. Among military personnel, this stereotype may also be influenced by

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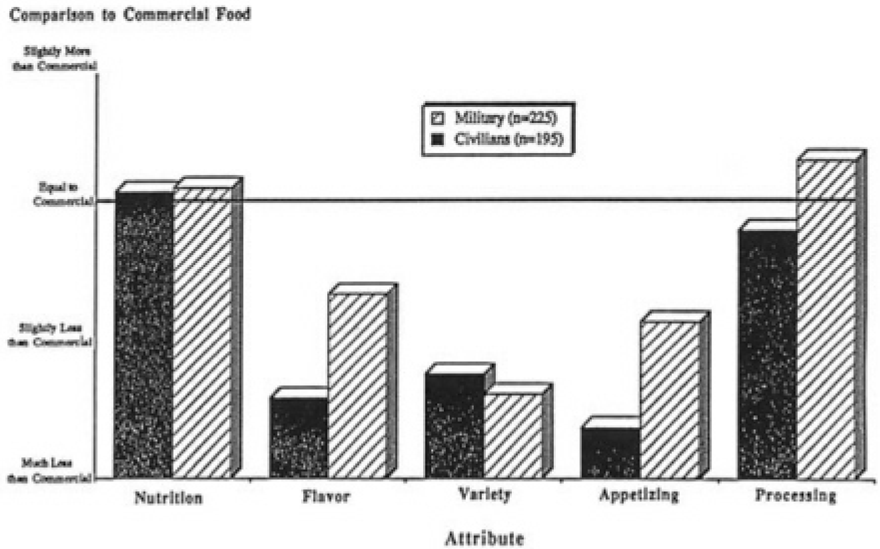


**FIGURE 10-5**

Ratings of military and civilian subjects comparing military to commercial food on five different perceived attributes of the food.

SOURCE: A. V. Cardello and R. Bell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995).

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negative associations with military food during basic training or early military assignments. Given this strong negative image of rations, the next question is whether such an image can affect the perception and acceptance (liking or disliking) of the rations when they are eaten. If so, this negative image may be an important factor contributing to the underconsumption of rations.

## THE ROLE OF CONSUMER EXPECTATIONS IN FOOD ACCEPTANCE

### Informational Variables

In a series of studies begun in the author's laboratory in 1985 (Cardello et al., 1985), the role of informational variables (e.g., product name, brand labeling, packaging, nutritional information, and product information) has been examined for its effect on the rated acceptability of military and other foods. This program has now evolved into a general program of research that investigates the role of consumer expectations on product acceptance. The basic premise of the research is that attitudes and information about food products create sensory and hedonic expectations for these foods. Subsequent perception and liking/disliking for a food is not simply a function of the intrinsic quality of the food. Rather it is a function of the expectations that a consumer has for the food and the degree to which the food matches or mismatches these expectations (see Cardello, 1994; Cardello and Sawyer, 1992).

Product names and brand labels are important informational variables that establish expectations and that can influence food acceptance. Data in Figure 10-6 are from a study (A. V. Cardello and R. Bell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995) showing the effect of militaryversus commercial-brand labeling on food acceptance. The test product was a commercial canned corn that was presented under two different informational conditions. Forty subjects first evaluated the corn in a blind taste test 1 month prior to the main test. The baseline acceptability of the corn from this blind taste test is shown as the horizontal line in Figure 10-6. The same subjects were then brought back 6 weeks after the baseline test for two more sessions, approximately 4 weeks apart. In one session, subjects were informed by written and visual information that the corn was a military (MRE) corn product. In the other session they were informed that it was a commercial (Green Giant brand) corn product. After receiving the information but before tasting the sample in each session, subjects were asked to rate how much they expected to like/dislike the corn, using a 9-point hedonic scale. Mean expected liking/disliking, obtained in this way, is shown by the arrows on the graph. Subjects then tasted the corn and rated its acceptability on the same 9-point hedonic scale. The data in Figure 10-6

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show that when subjects thought the corn was "military," they rated it significantly lower on both expected acceptability ($P < 0.01$) and actual acceptability ($P < 0.05$) than when the same corn was labeled as "Green Giant."

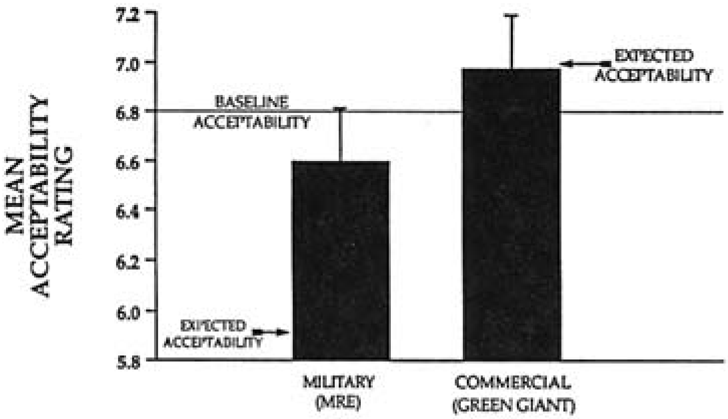


**FIGURE 10-6**
Mean acceptability ratings of the same commercial canned corn product when labeled as either military or commercial. The horizontal line at the top of the figure represents the baseline level of acceptability as determined from a blind taste test. The arrows indicate the levels of expected acceptability for the products as measured after the label information was presented but before the actual tasting.
SOURCE: A. V. Cardello and R. Bell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished manuscript, 1995).

Note in Figure 10-6 that the actual acceptability ratings shifted from their baseline level in the direction of the expected liking. Although this result may seem intuitive, one might argue that if subjects expected a poor product but received something better, they might overcompensate and rate the product higher than they would have otherwise. Similarly, if they expected something better than what was received, they might rate the product lower than if they had not held the higher expectation. This issue of the direction of change in acceptability ratings relative to the level of expected acceptability lies at the heart of the theoretical issues involved in predicting the effect of disconfirmed expectations on perceived product acceptance.

## Models of Disconfirmed Expectations

In the consumer psychology literature, there are four models of the effect of disconfirmed expectations on perceived product performance. Table 10-3 schematizes the predicted effects of these models based on an expansion of the models to predict food quality and acceptability (Cardello, 1994). The first model is known as *assimilation* and was proposed by Sherif and Hovland

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(1961). Like all of the models, this model predicts that when the *intrinsic* quality or acceptability of the product matches its *expected* quality or acceptability (i.e., there is no disconfirmation), *perceived* quality or acceptability will be unchanged from the intrinsic or baseline level. However, if the expectation level is high but intrinsic quality is low (a state of negative disconfirmation), the assimilation model predicts that perceived acceptability will be elevated in the direction of the expected level. Similarly, if expectations are low but intrinsic quality is high (a state of positive disconfirmation),perceived acceptability is predicted to decrease in the direction of the lower expectation level.

TABLE 10-3 Summary of the Predicted Effects of Disconfirmed Consumer Expectations on the Direction of Increase/Decrease in Perceived Product Performance for the Assimilation, Contrast, Generalized Negativity, and Assimilation-Contrast Models

| | Product Performance versus Expectation | |
|---|---|---|
| Model | Product Better Than Expected (Positive Disconfirmation) | Product Worse Than Expected (Negative Disconfirmation) |
| Assimilation | Decrease | Increase |
| Contrast | Increase | Decrease |
| Generalized negativity | Decrease | Decrease |
| Assimilation-Contrast | Decrease (under low disconfirmation) or increase (under high disconfirmation) | Increase (under low disconfirmation) or decrease (under high disconfirmation) |

The second or *contrast model* (Sherif and Hovland, 1961) predicts just the opposite effect. If expectations are high but intrinsic quality or acceptability is low, perceived acceptability is predicted to decrease below its intrinsic level. Concomitantly, if expectations are low and actual intrinsic quality is high, perceived acceptance is predicted to increase.

A third model, known as *assimilation-contrast* (Hovland et al., 1957) is a hybrid of the first two and maintains that perceived product quality will conform to the assimilation model predictions under conditions of low-positive or low-negative disconfirmation (product not very different from expectation), but will conform to the contrast model predictions under conditions of high disconfirmation (product very different from expectation).

The last model, *generalized negativity*, was proposed by Carlsmith and Aronson (1963). This model predicts a reduction in acceptance under all conditions in which expectations are not met.

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## Assimilation Effects

Over the past 25 years, the bulk of empirical research on the role of disconfirmed expectations on product performance has supported an assimilation model of these effects (Anderson, 1973; Bearden and Teel, 1983; Oliver, 1977; Olshavsky and Miller, 1972). Unfortunately, until recently, relatively few studies have examined these effects using food as the test product. However, one such study (Olson and Dover, 1976) examined the effect of consumer expectations on the belief strengths for the bitterness of coffee. These investigators employed an experimental group of 20 subjects who received a series of written communications about the test coffee prior to tasting it. Information in these communications consisted of advertising copy that extolled the coffee as having "no bitterness." Subjects in the experimental group also received a questionnaire asking them to indicate their strength of belief that the coffee was "not at all bitter," "somewhat bitter," "fairly bitter," or "very bitter." Following data collection, the average of these ratings served as a measure of expected bitterness for this group. Four days after the last communication, subjects met to taste the coffee, which was actually brewed to have considerable bitterness. Subjects rated the bitterness of the coffee by using the same descriptive categories and assigning belief strengths to each. A control group of 18 subjects received no written communication, but merely attended the tasting session and evaluated the coffee using the same rating scales.

The data from this study are shown in Figure 10-7. For all bitterness categories, the rated belief strengths of the experimental group "moved away from the pretrial expectancy and towards, but did not achieve, the objective post-trial belief strength of the control group" (Olson and Dover, 1976, p. 173). Investigators concluded from these data that "the direction, if not the magnitude of each post-trial belief expectancy change constitutes a perfect example of an assimilation effect" and that "these findings of consistent assimilation effects are in agreement with the results of virtually all the earlier disconfirmation research in marketing" (Olson and Dover, 1976, p. 173).

In several studies from the author's laboratory, strong assimilation effects have been shown using a variety of foods as the test products. Figure 10-8 presents data from a study on cola beverages (Cardello and Sawyer, 1992) in which 163 subjects were led to expect that they would receive one of several cola beverages. The cola expected for different subjects ranged from their favorite brand to their least favorite brand, as determined in prior blind taste tests. However, in some cases subjects were given the cola they expected, while in others they were given either a more preferred or a less preferred cola. Pretrial expected acceptability and post-trial actual acceptability were obtained from all subjects. The ordinate in Figure 10-8 is the change in product acceptance from baseline level as a function of whether subjects

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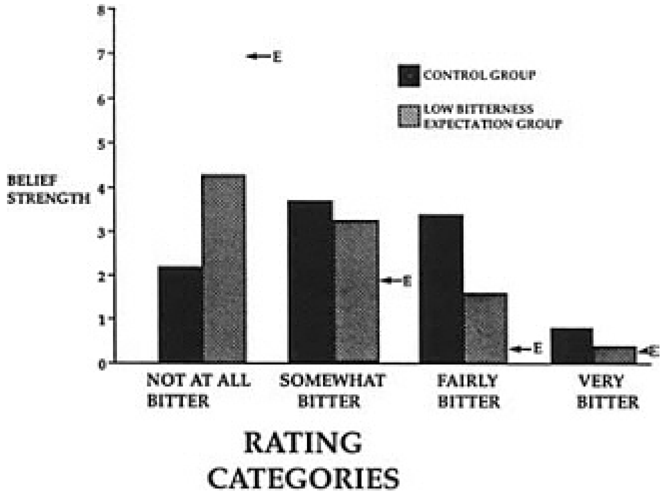


**FIGURE 10-7**

Mean ratings of belief strength for four different belief categories of the bitterness of coffee. The arrows (*E*) index the levels of expected belief strengths about the bitterness of the coffee for the subjects in the "low bitterness expectation group.

" SOURCE Adapted from Olson and Dover (1976).

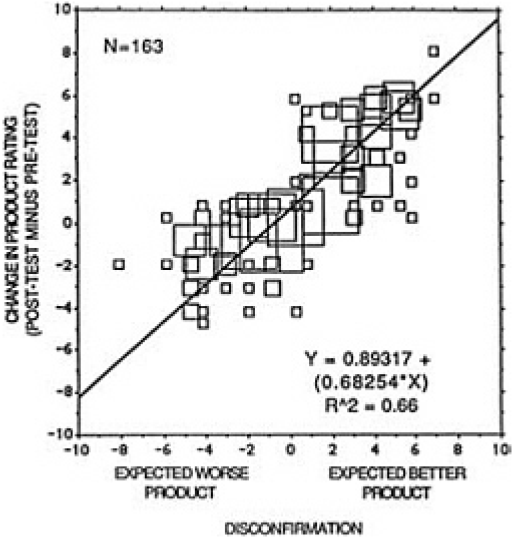


**FIGURE 10-8**

Plot of the change in product rating (acceptability) from pretest levels as a function of the degree to which subjects expected a better or worse cola product. SOURCE: Cardello and Sawyer (1992), used with permission.

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expected a better or worse product. The strong linear association ($r2$ = 0.66) in the data reflects the fact that acceptance moved in the direction of the expectation, which supports an assimilation model.

Similarly, in a recent study by Tuorila et al. (1994) in which the same experimental paradigm was used as above, subjects were led to expect that they would receive either fat-free or regular-fat pound cake, cheese, and/or crackers. In fact, subjects received either the expected product or its unexpected counterpart. Pretrial expected acceptability and post-trial actual acceptability were obtained from all subjects. Results in Figure 10-9 are from subjects who participated in only the cracker portion of the study. However, these data parallel the results found for pound cake and cheese. Like Figure 10-8, the data in Figure 10-9 show a strong, positive, linear association between the change in product rating and subjects' expectations, which provides support for an assimilation model of the effect of disconfirmed expectations on food product acceptance.

Although the bulk of the data collected to date supports an assimilation model, contrast effects do occur. Debra A. Zellner (Department of Psychology, Shippensburg State University, unpublished data, 1992) has shown contrast effects using extremely high levels of disconfirmation. For example, she has given subjects a medicinal tasting pill, telling them that it is either medicine or candy. Results obtained under these conditions show evidence of contrast effects. However, the majority of data from studies working within the levels of disconfirmation that are likely to be found with traditional food products show assimilation effects.

## Implications of an Assimilation Model

The implications of an assimilation model for ration acceptance are two-fold. First, on the negative side, if expectations of rations are low, the assimilation model predicts that acceptance will suffer. Thus, given the negative image and negative expectations of military rations as outlined at the start of this chapter, one may very well expect reduced acceptability for field rations. However, on the positive side, if expectations can be elevated, acceptance should increase. This latter prediction is consistent with the assumption operating in commercial advertising and food marketing, whereby products are "hyped" on the basis of their positive features and qualities.

However, for the purpose of identifying strategies to overcome underconsumption, the important question is not whether acceptance increases or decreases in response to changing expectations, but more directly, whether consumption increases or decreases in response to these changes.

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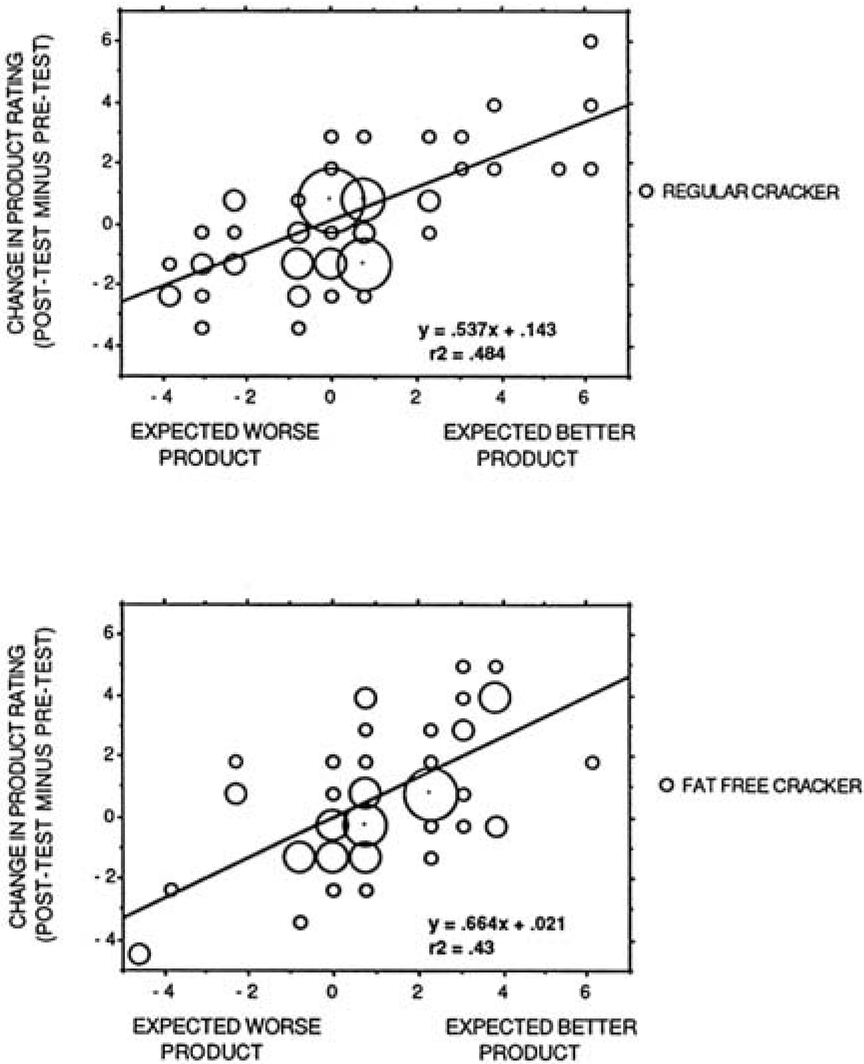


**FIGURE 10-9**

Plot of the change in acceptability ratings from pretest levels as a function of the degree to which subjects expected a better or worse product. *Top*, ratings for a regular fat cracker labeled as either regular fat or fat-free. *Bottom*, ratings of a fat-free cracker when labeled similarly.

SOURCE: Tuorila et al. (1994), used with permission.

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## EFFECTS ON CONSUMPTION

### Effects of Information and Packaging

On the basis of previous research showing that food preference and acceptance measures constitute up to 50 percent of the variability in consumption measures (Kamenetzky and Pilgrim, 1958; Pilgrim, 1961; Seaton and Peryam, 1970; Sidel et al., 1972; Smutz et al., 1974; Sullins et al., 1977; Wyant et al., 1979), one can argue that any variable that affects food acceptance will, in turn, affect consumption of that food. However, data are now beginning to emerge that indicate a direct relationship between consumer expectations (and/or the informational variables that have been shown to control expectations) and consumption. For instance, in a recent study by Hellemann et al. (1993), 79 consumers were served a low-fat meal, but half were told that the items were low-fat, while the other half received no information. Pretest measures of expected liking were obtained, as well as posttest measures of acceptability, likelihood to purchase the meal items, and actual consumption. Results indicated that disconfirmed expectations produced negative affect (acceptability), a lower likelihood to purchase the product, and reduced consumption of the food.

In another series of studies, image-related informational variables concerning military food were investigated for their effect on both the perceived acceptance and consumption of the food. In the first of these studies, Kramer et al. (1989) served four different flavors of pudding to 58 subjects in one of three different containers—a plain white bowl, a military (khaki-colored) bowl, or a military (khaki-colored) pouch. It was predicted that the military package conditions would generate lower expectations for the pudding and, in turn, reduce acceptance and consumption. Consistent with this hypothesis, subjects rated the acceptability of the pudding in both military packages lower [$F$ (2, 55) = 5.96, $P$ < 0,01], and as shown in Figure 10-10, ate significantly less of the product [$t$ (56) = 2.44, $P$ < 0.05]. The same subjects were then brought back 4 months later, at which time all of them were presented with the puddings in their normal commercial packaging (Hunts brand). As seen in Figure 10-10, there were no significant differences in intake among the groups; and the two groups that were previously given the pudding in the military containers now ate significantly more of the puddings ([$t${14} = 3.80, $P$ < 0.01] for military bowl; [$t${19} = 3.81, $P$ < 0.001] for military pouch).

Working on the assumption that commercial packaging creates a higher expectation than military packaging, Kalick (1992) undertook a study to determine if ration acceptance and consumption could be increased by altering ration packaging to look more like commercial packaging. Primary and secondary packaging of the standard combat ration Meal, Ready-to-Eat (MRE)

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were given commercial-like colors, labeling, and graphics. Two different commercial-like designs were created. Both designs, along with the standard MRE package design, were used to package identical MRE meals. Subjects—192 military troops stationed at Fort Campbell, Kentucky—were divided into three groups, and each person received a single meal packaged in one of the three alternative designs while on a field mission. The three test groups were spatially separated to prevent communication about the packaging manipulation. Subjects rated the acceptability of each of the components of the meal, the overall meal acceptability, the acceptability of the packaging, as well as other nonfood aspects of the ration (e.g., the effectiveness of the ration heater). Consumption of items in the meal was measured by visual estimation. As shown in Table 10-4, the mean acceptability ratings for the entree (chicken stew), the beverage (orange drink), and two of the candies (Tootsie Roll and Charms) were significantly higher when packaged in either of the commercial-like packages than when packaged in the traditional MRE package. Unfortunately, the consumption data were confounded by the fact that the MRE group

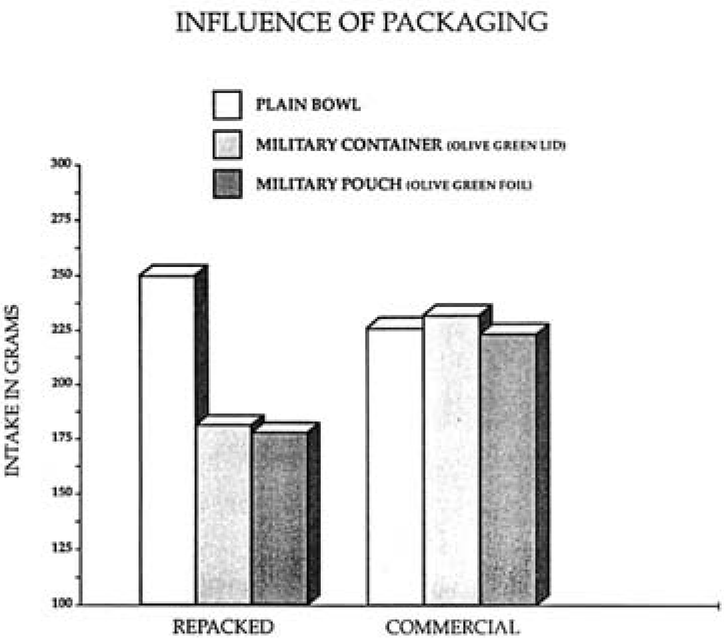


**FIGURE 10-10**
Mean intake (g) of subjects exposed to commercial puddings in either a plain bowl, military container, or military foil pouch ("repacked").
The data labeled "commercial" were collected several weeks later from the same subjects when exposed to the puddings in their regular commercial packages. SOURCE: Kramer et al. (1989), used with permission.

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missed breakfast on the day of the test, so their hunger ratings were significantly higher than those for the two commercial package groups [$F$ (2, 189) = 4.98, $P < 0.05$]. In spite of the increased hunger in this group, subjects in the MRE package group ate no more of the ration than subjects receiving rations in either of the two commercial-like packages.

TABLE 10-4 Mean Acceptability Ratings of Ration Items for which Statistically Significant Differences (P < 0.05) were Found as a Function of the Type of Packaging Used

| | Mean Acceptability Rating by Package Type | | |
|---|---|---|---|
| Food Item | MRE | NEW 1 (BEIGE) | NEW 2 (GREEN) |
| Entree (chicken stew) | 5.8 | 6.8 | 6.8 |
| Beverage (orange drink) | 5.8 | 6.6 | 7.2 |
| Candy (Tootsie Roll brand) | 7.5 | 7.5 | 8.2 |
| Candy (Charms brand) | 6.0 | 6.4 | 7.2 |

SOURCE: Kalick (1992).

## Effects of Social Communications

Lastly, Engell et al. (1990) demonstrated that the opinions of a group leader about ration quality directly affected ration consumption. In this study, two cohorts of military personnel participated in lunch-time meal tests of rations. Participants in each group were members of the same platoon, and neither group knew that their platoon sergeants had been recruited to serve as confederates (allies) in this study. Each platoon assembled in a dining room to eat and evaluate "new rations." In one condition, the sergeant accompanied the troops into the dining room, sat at their table, began to eat the rations, and proceeded to make negative comments about the quality and acceptability of the new rations. In the other condition, the sergeant followed the same procedure, but made only positive comments about the quality and acceptability of the new rations. Following the meal, subjects evaluated the rations for acceptability on a 9-point hedonic scale, and subsequently, the amount they consumed was indexed using a plate waste measure. The rated acceptability of the rations was significantly higher in the condition in which the sergeant made positive comments about the rations when compared to the condition in which the sergeant made negative comments about the rations. More importantly, the data in Figure 10-11 show that the subjects in the positive

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communication condition consumed significantly more total calories than did subjects in the negative communication condition [$t$ (27) = 2.36, $P < 0.05$)].

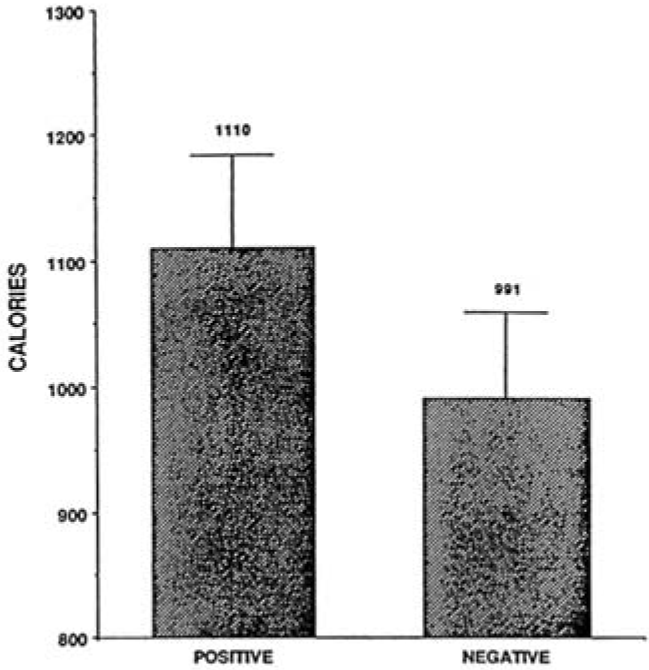


**FIGURE 10-11**
Mean energy intake of a tray-pack ration in kilocalories for troops participating in a lunch study on social influence. The data on the left were collected from troops who were exposed to positive communications by a confederate. The data on the right were collected from troops who were exposed to negative communications.
SOURCE: Engell et al. (1990), used with permission.

## CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from the data presented in this chapter:

- A strong negative image of military rations exists.
- The negative image is the same among both consumers (soldiers) and nonconsumers (civilians) of the ration products, which suggests that the image is stereotypical.
- Data on the effect of disconfirmed expectations on product acceptance support an assimilation model.

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- The implications of an assimilation model for ration acceptance are: (a) the negative image of rations will decrease their acceptance and consumption, and (b) improving the image will increase ration acceptance and consumption.
- Recent studies manipulating expectations of rations through information and packaging show positive effects on rated acceptance.
- Effects of expectations and/or informational variables on consumption, although fewer in number, are now being demonstrated.

Based on the available data, the following recommendations are made in support of the goal of developing strategies to overcome underconsumption of rations:

- Conduct a detailed analysis of all factors contributing to the current negative image and expectations for military field rations, including sources both inside and outside the military.
- Develop a program to improve the image of and expectations for military rations among soldiers, using as vehicles: (a) informational communications (e.g., pamphlets and training videos that emphasize the quality and acceptability of field rations), (b) commercial-like packaging that creates a more positive image of the contents of the package, and (c) commercial-brand labeling to take advantage of positive associations that have been created with these brands.
- Continue basic research into the cognitive mechanisms by which attitudes and expectations affect ration and product perception, acceptance, and consumption.

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## DISCUSSION

EILEEN THOMPSON: The whole idea of a shelf-stable, packaged, pouch food in itself has a negative reaction quite separate from the military site. We did some studies where we compared frozen products like spaghetti and meat sauce with a shelf-stable product called Top Shelf. When we did it "blind", the Top Shelf product was definitely preferred over the frozen product. But as soon as the study participants knew that one was frozen and one was shelf-stable, the scores were completely reversed, and the frozen product was preferred.

ARMAND CARDELLO: Yes, the variables that control that are important.

HOWARD SCHUTZ: (Off mike.) — If we look to the consumer behavioral literature, I think we have to have some concern about how far we take this issue of packaging. That is, if you increase the expectations based on packaging a great deal because we know that satisfaction is related to disconfirmation, at some point they're going to be expecting so much and be disappointed.

ARMAND CARDELLO: Yes, I could have expanded on the other model, the assimilation contrast model, which basically says that you get assimilation effects when the product comes close to the expectation in either direction. However, when the actual product characteristics differ greatly from the expectation, you get a reversal and then a contrast effect.

RICHARD JANSEN: How do you explain the MRE food acceptance rating data based on the theory you've presented? They've had this food, they've had bad expectations. They eat it, it's probably not that great, they don't eat that much of it, and yet they rate it a seven. In other words, why aren't those acceptance ratings lower if in fact this model is going to hold?

ARMAND CARDELLO: I think part of the explanation goes back to John De Castro's previous point. I think that when I go home and select the fruit that I want, the sandwich that I want, I'm going to rate that an eight or a nine. These ratings here appear to be moderate, but in fact they're probably not as high as the ratings they would give food that they chose and selected. So I

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think we have to be careful of how we characterize ratings of six and seven. Is it low? is it high? Is it acceptable? I think it is in fact on the low end because the people don't choose the food that they actually want.

RICHARD JANSEN: I hate to be pessimistic, but I think rehabilitating the image of the MRE is about as probable as rehabilitating the athletic prowess of Gerry Ford. It is past the point. You would have to bribe every cartoonist and every talk show host in the country. I think you're on the right track, in terms of the fact that the MRE needs to be perceived as commercial food. When it is perceived that way, they in fact consume it. Now one of Vice-President Gore's "Re-inventing Government" mandates is getting away from military specifications for a whole raft of items. In other words, you don't need to have a particular specification for a toilet seat; you can use a commercial toilet seat instead. I would think that would include the use of commercially produced and labeled foods in military rations.

ARMAND CARDELLO: One of the things I want to point out is that changing attitudes is much more difficult than establishing attitudes. I think any of these efforts needs to be done with new rations as they're being fielded, rather than to go back, and as you say, rehabilitate the MRE image.

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# 11

# Effects of Food Quality, Quantity, and Variety on Intake

*Barbara J. Rolls*[1]

## INTRODUCTION

A number of highly controlled laboratory-based studies have tested whether modifications either to foods or meals can increase energy intake. One approach is to choose foods that are not very satiating, that is, calorie-for-calorie they reduce hunger less than other foods. Another approach is to alter the way the food is served so that portions are bigger or the meals are more varied. These studies will be reviewed and ways that foods might be altered to influence energy intake will be considered.

## SATIETY AND FOOD INTAKE

The main reason that individuals choose particular foods is because they like the taste. While palatability of foods was found to be a major determinant

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of intake in an extensive review of the literature on human food intake (Spitzer and Rodin, 1981), it is possible that other characteristics of foods such as the energy density or nutrient composition could have an impact on energy intake.

## Energy Density and Food Intake

Various types of foods satisfy hunger differently (Kissileff, 1984; Rolls et al., 1990). The reasons for these differences in satiating effects are not clear. Among the causative factors that have been suggested are rate of consumption of a food, the sensory properties of the food, and beliefs about the satiety value of a food (Kissileff, 1984)/

Soup is an example of a food that is highly satiating. In a clinical survey in which intakes were analyzed from food diaries, Jordan et al. (1981) found that meals that included soup were associated both with lower caloric intakes within the meals and with lower daily caloric intakes than those meals without soup. Several studies have confirmed that soup is a highly satiating food (Kissileff et al., 1984; Rolls et al., 1990). At least part of the explanation is the low energy density of soup. Energy density, that is the calories in a given weight of food, could affect satiety by influencing the rate at which nutrients reach receptors involved in satiety (Kissileff, 1985). Foods with a low energy density require that a greater bulk of food be consumed for a given level of energy intake. The bulk of food to be consumed affects eating rate, gastric distension, and intestinal stimulation. Also, it is likely that individuals have learned the appropriate portion sizes that they should eat to experience satiety.

Energy density of foods can affect daily energy intake and body weight. In one study (Duncan et al., 1983), obese and normal-weight subjects had access to one of two different diets, for 5 days each. One diet had twice the energy density of the other; the low-energy-density diet was low in fats and sugars and high in fiber. The subjects consumed three meals a day and were allowed to eat as much of the available foods as they liked at each meal. Subjects on the high-energy-density diet. consumed nearly twice as many calories as those on the low-energy-density diet. Subjects on the low-energy-density diet were slightly hungrier at mealtimes but found the meals to be satiating. The diets in this study differed not only in energy density, but also in the fat content and in the amount of fiber, both of which could affect the amount of food consumed.

## Dietary Fat and Food Intake

Foods high in fat can be readily overeaten, not only because fat increases the energy density of foods, but also because it contributes to the palatability of foods (Drewnowski, 1988). A key question is whether fat and carbohydrate,

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the principal macronutrients of most diets, have similar effects on hunger and satiety since, if the proportion of fat in the diet is reduced, the proportion of carbohydrate will increase. Dietary fat may be overconsumed because it is not as satiating as other nutrients, which would relate to postabsorptive factors such as nutrient absorption, hormonal release, and oxidation of nutrients (Rolls and Shide, 1992).

Rolls et al. (1992) have conducted a number of studies that compared the effects on subsequent food intake of eating equicaloric amounts of foods that varied in fat and carbohydrate content. Results indicated that in normal-weight men who were unconcerned with their body weight, foods differing in fat and carbohydrate content were equally satiating in that they similarly affected subsequent food intake. However, in individuals who were overweight or who were concerned with their body weight, yogurt that was high in fat suppressed subsequent intake significantly less than did yogurt that was high in carbohydrate. This result suggests that in some individuals there could be a relative insensitivity to the satiety value of fat in foods. Future studies will determine whether this insensitivity plays a role in the etiology or maintenance of obesity.

Two studies conducted at Cornell University suggest that it is difficult to maintain body weight when consuming a diet composed only of low-fat foods. In the first study (Lissner et al., 1987), females of varying body weight consumed sequentially three 2-wk dietary treatments in which the energy consumed as fat was 15–20 percent, 30–35 percent, and 45–50 percent, respectively, of the diet. Relative to their energy consumption on the medium-fat diet, which resulted in significant changes in body weight. In the second study (Kendall et al., 1991), female subjects consumed a low-fat diet (20–25 percent fat) or a control diet (35–40 percent fat) for 11 weeks each, with a 7-wk washout period (when they ate their usual diets) between conditions. Results showed that subjects ate less total energy on the low-fat diet and lost twice as much weight as on the control diet. In both of these studies, subjects ate the same weight of food in the various conditions, which suggests that the weight or volume of food consumed is an important determinant of energy intake.

In another recent study, Prewitt et al. (1991) lend support to the suggestion that the fat content of the diet can have marked effects on body weight maintenance. Over a 20-wk study in lean and obese premenopausal women, a significantly greater energy intake was required to maintain subjects' body weight on a 21 percent fat diet than on the 37 percent fat maintenance diet. The authors concluded that macronutrient composition may play a role in energy requirements for weight maintenance.

When underconsumption is a problem, it is clear that the fat content or energy density of available foods can significantly affect food intake and body

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weight. High-fat foods are easier to consume in quantity because they are often highly palatable, a smaller volume is required to achieve a given caloric intake, and possibly they are less satiating. To determine the optimal percentage of calories from fat in the diets of military personnel, concerns about underconsumption of energy will need to be balanced against problems that may be associated with a high-fat diet.

### Dietary Fiber and Food Intake

Dietary fiber could reduce food intake for a number of reasons (Levine and Billington, 1994):

- high-fiber foods take longer to eat,
- some fibers such as guar gum and pectin slow gastric emptying,
- fiber may reduce the digestibility of food,
- increased fecal loss of energy may occur on high-fiber diets, and
- fiber may affect some gastrointestinal hormones that influence food intake.

Because of the different types and doses of fiber that have been tested and the wide variety of experimental protocols, the literature on this topic is complex. Nevertheless, a number of studies have shown that high-fiber foods consumed either at breakfast (Burley et al., 1993a; Levine et al., 1989; Turconi et al., 1993) or lunch (Burley et al., 1993b; Turnbull et al., 1993) significantly reduce intake at the next meal when compared to low-fiber foods. A number of studies have also investigated the effects on weight loss of supplementing of the diet with fiber over longer periods of time (Levine and Billington, 1994; Stevens, 1988). While several of these studies show a slightly greater weight loss for subjects on a fiber-supplemented diet, the results of the studies are variable and difficult to interpret. More well-controlled studies are required that compare the effects of different types of fiber in various doses to the effects from diets of equivalent energy and protein without added fiber.

## QUANTITY AND FORM OF FOOD

### Portion Size

There is a strong tendency in many individuals to finish the food they are given, that is, to "clean the plate" (Krassner et al., 1979). Therefore it is likely that portion size will affect the amount of food eaten, although there is little published research on such effects. In one study, Shaw (1973) found that subjects consumed more of a liquid diet when it was presented in 8-oz (237-ml)

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cups rather than in 2-oz (59-ml) cups. Booth and colleagues (1981) also found that when subjects were served portions 11/2 times larger than the standard portion of a variety of foods, there was an increase in the total amount consumed. However, a subsequent study (Edelman et al., 1986) found that increases in portion size resulted in enhanced consumption only when the portions were increased by about 4 times. When subjects were fed either 255 g or 426 g of lasagna, there was no difference in intake. However, when the portion size was increased to 1,000 g, intake was increased. Finally, in a recent study (D. Engell, M. Kramer, and B. Rolls, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1994), subjects were served three portions of macaroni and cheese for lunch (450, 620, and 790 g) on separate days. A significant linear relationship was found between portion size and intake. There are a number of differences among the studies, and it is not clear which of these might have influenced the results. Clearly, more studies are needed to determine situations in which portion size can affect food intake.

This author and S. Stoner (Pennsylvania State University, unpublished data, 1994) tested whether altering the way food is presented can influence food intake. Intake was compared when subjects were offered the same number of sandwiches, presented either as substantial whole units or as dainty cocktail pieces. Results showed that men ate significantly more (approximately 10 percent) of the whole sandwiches than of the sandwiches cut into parts, but women's intake showed no difference between the conditions.

Results of these studies indicate that simple changes in the way food is presented can significantly affect energy intake. Because studies thus far have only been conducted during a single meal, it is not clear whether altering food presentation can affect daily or longer-term energy intake.

## Form of Food

Because hunger and thirst are regulated by different mechanisms, it is possible that offering solid and liquid forms of food could have different effects on the amount consumed. In one study, Kissileff (1985) compared consumption of a liquefied yogurt with that of a solid yogurt. He found no differences in the amount consumed, but the liquid yogurt was consumed faster. Two additional studies examining the forms of food on intake have been conducted in France (Tournier and Louis-Sylvestre, 1991). In these studies, the design is based on presenting the subjects with a fixed amount of test foods or preloads at set-time intervals and recording subsequent intake of either experimental or regular foods. In the first study, the two preloads had the same caloric content, weight, volume, composition, and temperature, but differed in physical form (a savory soup versus a pâté). Results showed that the 24-h intake was higher following liquid food than solid food consumption, but the

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difference was not statistically significant. The second experiment was designed to control for cognitive and masticatory differences between solid an liquid preloads. Subjects had both a solid and a liquid in each preload, but in one condition most of the calories were in the liquid, and in the other, most were in the solid phase. Food intake during the 24 hours following the preloads was significantly higher (20 percent) for subjects who consumed most of the calories in the drink. This result could be because liquid calories are less satiating than those in solids, or it could be that the situation of taking most of the calories as a drink was unfamiliar. Perhaps over time subjects would adjust subsequent intake according to the calories in the preloads.

### Food Labels

Through their experiences of consuming foods and through messages associated with particular foods, individuals learn to consume amounts of foods appropriate for the satisfaction of hunger (Booth, 1985; Johnson et al., 1991). Thus, the perceptions that individuals have of foods may affect the level of satiety associated with those foods, at least until experience proves these perceptions false. Rolls et al. (1992) tested the hypothesis that the perception of the fat content of foods may have an effect on consumption. Normal-weight women were given two different equicaloric yogurts, one labeled "low-fat" and the other labeled "high-fat." The subjects ate significantly more at lunch shortly after consuming the yogurt labeled "low-fat" than after consuming the yogurt labeled "high-fat." In another study (M. Kramer, J. Edinberg, S. Luther, and D. Engell, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1989), the palatability and consumption of pudding packaged in either commercial, military, or neutral packages were compared. The pudding in the military package was rated lower in palatability and significantly less of it was consumed than when it was served in the other packages. These studies demonstrate that perceptions of foods can affect food intake. More studies are required to determine how such perceptions affect food consumption over longer periods of time.

## SENSORY-SPECIFIC SATIETY AND VARIETY

### Changing Hedonic Responses to Foods During a Meal

In 1958, Siegel and Pilgrim stated that "the rejection of rations by enlisted personnel is often accompanied by the complaint that the food is monotonous. This observation suggests that repetition is a causal factor in lowered food-acceptance" (p. 756). Since that observation, studies have shown why humans desire and eat a variety of foods. The hedonic response to a food as assessed

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by ratings of the pleasantness of its taste and other sensory attributes is not constant, but changes as a food is consumed.

This changing hedonic response to foods, or sensory-specific satiety, has been characterized in a series of laboratory-based studies. Rolls (1986) found that satiety, or the feeling of having had enough to eat, is specific to a particular food that has been consumed. If, for example, cheese is eaten until a subject has had all he or she wants, the rated pleasantness of the taste, smell, appearance, and texture of cheese will have declined. However, ratings of the sensory properties of other foods, particularly those very different from cheese, will not have decreased. These changes in pleasantness are related to the amounts of various foods that will be eaten during a meal. One may have eaten enough of a particular food and that food will no longer be appealing, but the appetite for other foods will remain. Thus sensory-specific satiety encourages consumption of a balanced diet because it promotes consumption of a variety of foods.

Although the greatest changes in palatability that occur after eating involve the food consumed, some uneaten foods may also decrease in palatability. This phenomenon might occur because (1) these other foods have sensory properties similar to the eaten food, (2) cognitively the foods are considered to be of the same type, or (3) perhaps the foods have the same macronutrient content (Rolls, 1986).

Thus, if foods are similar in taste to the food already consumed, they may also decrease in pleasantness. For example, after consumption of one sweet food, other sweet foods declined in pleasantness, but savory foods (i.e., salty and not sweet) were unaffected. Similarly, consumption of savory foods decreased the pleasantness of other savory foods but not sweet foods (Rolls et al., 1984). A recent study (de Graaf et al., 1993) has clearly demonstrated that consumption of sweet foods in a first course decreases the intake of sweet foods in the next course and, likewise, consumption of savory foods decreases the subsequent consumption of savory foods.

Individuals also become satiated to specific categories of foods (Rolls et al., 1986). For example, following consumption of orange gelatin, raspberry gelatin also declined in pleasantness. Similarly, following ingestion of tomato soup, consommé also decreased in pleasantness. These effects are probably due both to the way in which foods are cognitively grouped together and to similarities in the sensory properties of the foods.

Thus our perceptions of foods interact with one another so that consumption of one food may affect the pleasantness of other foods. Findings from further studies of such interactions could be used for meal planning. The goal would be to find foods that show little interaction so that palatability can be maintained at a high level throughout a meal. Meal patterns in many cultures already stress the importance of different sensory qualities of foods throughout a meal. A meal of soup or salad followed by meat with vegetables and ending

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with dessert, with an emphasis on contrasts in color and texture, would reduce the possibility of specific satieties diminishing appetite during the meal.

Possibly, the specificity of satiety may be due not only to the sensory properties of foods, but also to the macronutrient content. If, as suggested by other investigators, the need for particular nutrients is an important factor in the hedonic response to foods, this type of interaction would be expected (Cabanac and Duclaux, 1970). However, Rolls et al. (1988) tested for interactions between foods of similar macronutrient composition, and the data did not support the hypothesis that hedonic changes are due to the nutrient composition of foods.

## Variety and Intake During a Meal

If satiety is specific to particular properties of foods, then during a meal more should be consumed if a variety of foods is consumed than if just one food is presented (Rolls et al., 1986). In a series of experiments, it was found that variety in a meal can increase energy intake. For example, if subjects were offered a four-course meal consisting of foods that varied markedly in both sensory properties and nutrient composition, they ate 60 percent more total energy than when they had just one of the foods in the meal (Rolls et al., 1984).

These studies also tested to what degree foods could be similar in their sensory properties and still result in an enhancement of intake due to variety. Offering similar foods, such as sandwiches with four different fillings, increased intake by 33 percent (Rolls et al., 1981). Offering three different flavors of yogurt, which also differed in appearance and texture, increased intake by 20 percent compared to intake of the favorite flavor, but offering three different flavors of yogurt that did not differ in appearance or texture did not have an effect on intake (Rolls et al., 1982). Even offering in a meal the simple variation of three different pasta shapes increased intake by 15 percent compared to meal intake with only the favorite pasta shape (Rolls et al., 1982). These studies indicate that to maintain appetite throughout a meal and to encourage eating, the foods offered should be as varied as possible.

It must be emphasized that sensory-specific satiety and the effects of variety do not operate in isolation to affect food intake and selection. During normal eating, changing hedonic responses to foods will interplay with the complex environmental and physiological influences on food intake so that in some situations the palatability of foods may be the major influence on intake, while in others it may have little impact.

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## Monotony in the Diet

Thus far, the hedonic responses to foods during one meal have been considered. However, when assessing consumption of military rations, one must also consider changes in food acceptability and consumption that develop over longer periods. Why the acceptability of particular foods declines over time is not well understood, but one possibility is that eating a food too often affects acceptance. Studies of the effects of consuming monotonous military rations indicate that repeated presentation of some foods can lead to a persistent decrease in the pleasantness of these foods (Schutz and Pilgrim, 1958; Siegel and Pilgrim, 1958). For example, with repeated consumption, canned meats became very unpalatable and continued to be disliked for 3 to 6 months after the study. Note, however, that canned meats were not rated as very palatable at the start of the study. The effects of repeated consumption appear to be different for staple foods and foods of initial high palatability. Thus, repeated consumption did not change the palatability of desserts, sweets, canned fruits, cereal, or staples such as dairy products, bread, or coffee (Schutz and Pilgrim, 1958; Siegel and Pilgrim, 1958).

Moskowitz (1979) has described "time-preference curves" for different types of foods, which indicate that foods not consumed for about 3 months are highly desired, but those eaten the day before may not be desired at all. Foods such as meat and shellfish, foods with a heavy fat content, or foods that constitute the main component of the meal such as the entree have steep curves and are greatly desired if not eaten for a long period. Recent consumption, however, eliminates the desire for such foods. In contrast, items that are not a major component of the meal and do not have a high-fat or protein content such as bread, salad, potatoes, and some desserts have a much flatter function on the time-preference curves (hence less significant impact on preference) and could be eaten every day with no loss of preference.

Because repeat consumption of foods has been shown to lead to decreased acceptance, it is worth considering ways to avoid these monotony effects. Creating diets as varied as possible is recommended. Also, ensuring that the initial palatability of the foods offered is uniformly high should help to curtail the decline in pleasantness. One way of improving initial acceptability is to allow self-selection of items whenever possible. Kamen and Peryam (1961) found that self-selection of items to be included in a repetitive diet reduced dissatisfaction with the diet. Thus overall satisfaction with a 3-d, self-planned menu cycle was the same as with a 6-d cycle chosen by someone else.

Making people eat foods that they have not selected themselves can decrease the preference for those foods. This notion is supported by studies of young children, in which foods they were forced to eat in order to gain rewards decreased in preference (Birch et al., 1982). Much more research is needed to determine what causes the decrease in acceptability of foods.

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### Variety and Body Weight

Body weight maintenance may depend to some extent on the availability of a varied and palatable diet. In studies of the effects of consumption of a monotonous liquid diet, it was found that the subjects voluntarily restricted their intake and lost weight (Cabanac and Rabe, 1976; Hashim and Van Itallie, 1965). Although it is difficult to conduct controlled studies in humans, some evidence exists that if freely available diets are varied and palatable, subjects may show excessive weight gain. In studies of normal-weight and obese individuals confined to the hospital, a plentiful and varied supply of food led to overeating and weight gain over 3- to 6-d periods (Porikos et al., 1977, 1982).

The varied and palatable diets available in affluent societies probably contribute to the high incidence of obesity. When there is continual appetite stimulation created by variety both within and between meals, there will be little opportunity to compensate for overeating due to variety without conscious limitation of intake.

## CONCLUSIONS AND RECOMMENDATIONS

Highly controlled laboratory-based studies have pointed to a number of ways in which the preparation and selection of foods in a meal can influence the amount consumed. Although much of this research has yet to be applied to naturalistic settings where the goal is to alter the amount consumed, the studies suggest strategies that could be used to increased consumption of military rations. These strategies include the following:

- The initial palatability of foods should be high in order to delay a decreased intake due to repeat consumption. Providing opportunities for self-selection of foods also helps to avoid such monotony effects.
- The diet should be as varied as possible both in terms of the number and types of food items offered and of the sensory properties of the foods. Variety of flavor, texture, and appearance of foods helps to maintain the palatability of a meal and can affect the amount consumed.
- The way that foods are presented, such as the portion size, can affect the amount consumed. To satisfy the dual goals of maximizing intake and avoiding wastage, it may be necessary to allow some choice in portion size since intake varies widely between individuals.
- The labels on foods and the beliefs that individuals have about the satisfaction derived from particular foods can affect food intake.
- The energy delivered in drinks reportedly suppresses subsequent food intake less than the equivalent energy delivered in foods. Providing drinks of high nutrient and energy density could improve the diet and could increase food intake.

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- Daily energy intake is lower on low-energy density, high-fiber diets than on high-fat, energy-dense diets. In determining the optimal amounts of fat and fiber for the diets of military personnel, there must be a balance between the nutritional requirements of a healthy diet and those necessary for maintaining energy intake.

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# 12

# Effects of Beverage Consumption and Hydration Status on Caloric Intake

*Dianne Engell*[1]

## INTRODUCTION

Water intake is essential for survival and critical for optimal performance. It is generally recognized that adequate fluid consumption is important to military operations because hypohydration can lead to performance decrements and life-threatening heat injuries in hot climates (e.g., Adolph et al., 1947; Ladell, 1955; Pitts et al., 1944; Saltin, 1964). Drinking is also important to the health and performance of military personnel because of the contribution of beverages to energy intake. Beverage consumption has direct and indirect effects on caloric intake. The direct contribution of drinking to energy intake is obvious: beverages themselves are a good source of calories. The indirect influence on caloric intake is less apparent, but research indicates that limited fluid intake, when associated with hypohydration, leads to reduced food intake.

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This chapter will discuss both the direct and indirect effects on caloric intake of drinking water and nonalcoholic beverages. A brief overview of research addressing the sensory, psychological, and environmental influences on fluid consumption will also be presented to provide background information and a rationale for recommendations found at the end of the chapter.

## CONTRIBUTION OF BEVERAGE CONSUMPTION TO CALORIC INTAKE IN THE FIELD

The direct contribution of beverages to caloric intake in the field can be assessed from a data base of field study results that are part of the U.S. Army Natick Research, Development and Engineering Center's (NRDEC) ration testing program. While some of NRDEC's work on drinking behavior involves experiments designed specifically to determine the effects of sensory or situational factors on beverage consumption, other information on drinking behavior stems from the ration testing program in which rations are evaluated in realistic military field settings. The methodology for these field studies includes monitoring food and beverage intake and subjects' body weights and collecting acceptance ratings of rations and associated products such as packaging, heating devices, and utensils. In collaboration with the U.S. Army Institute of Environmental Medicine (USARIEM), NRDEC also monitors urine-specific gravity to assess hydration status. Data from these field studies serve not only as the basis for evaluating rations and related products, but they also provide insight into human eating and drinking behavior.

This discussion will focus on beverage consumption in field studies where the Meal, Ready-to-Eat (MRE) was the sole source of sustenance. The MRE is the primary operational ration when troops are deployed, a time when hypohydration is most common (see Kramer, Chapter 17 in this volume). Beverage consumption data from field studies of the MRE are an excellent source of information to determine the contribution of beverages to daily caloric intake in the field because different versions of the MRE have been tested repeatedly in different environments. The MRE data base is also the most extensive of the ration data bases.

Over the past 10 years, some of the food components in the MRE have been improved, others have been dropped, and new products have been added. A summary of these changes can be found in Chapter 7 of this volume by Darsch and Brandler. The beverage components, all of which are found in powdered form, have also changed over the years. The earliest versions of the MRE included a package of coffee in each meal and cocoa in 7 of the 12 menus. In response to feedback from soldiers and evidence indicating that flavoring enhanced water intake in the field (Engell and Hirsch, 1991), a

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package of fruit-flavored beverage powder was added to each MRE meal in addition to coffee and cocoa. This version of the MRE, with coffee and fruit-flavored beverages in all of the menus and cocoa in 7 of the menus, was produced from 1987 to 1992 (MRE VII-MRE XII). package of fruit-flavored beverage powder was added to each MRE meal in addition to the coffee and cocoa. In 1993, 6 of the 12 sugar-sweetened fruit drinks were replaced with aspartame-sweetened beverages. Future versions will substitute sugar-sweetened tea for coffee in 6 of the 12 menus. Additional beverages such as cider, carbonated beverage tablets, and shakes have also been tested as part of an accelerated development program called the Soldier Enhancement Program (SEP), but these additional beverages will probably not be included in the next version of the ration because of shelf-life requirements and costs. Table 12-1 summarizes the changes in MRE beverage composition from 1980 until 1993; Table 12-2 presents the nutritional composition of these beverages.

Five MRE field studies were analyzed to determine the contribution of beverages to overall energy intake (Engell et al., 1987; Hirsch et al., 1985; Lester et al., 1989, 1993; Popper et al., 1987). In each of these studies, which included two or more experimental groups, the average food and beverage intake reported for each group was based on data from at least 40 male soldiers consuming only the MRE for at least 1 week.

TABLE 12-1 Beverage Products Found in Meal, Ready-to-Eat (MRE) Rations

| MRE Version | Coffee | Cocoa | Bev Base | Sugar-Free Bev Base | Apple Cider | Shakes | Lemon Tea |
|---|---|---|---|---|---|---|---|
| I-VI | 12 | 7 | 0 | 0 | 0 | 0 | 0 |
| "Improved" & VII-XII | 12 | 7 | 12 | 0 | 0 | 0 | 0 |
| SEP-1991 | 12 | 0 | 6 | 0 | 1 | 4 | 1 |
| SEP-1992 | 11 | 1 | 9 | 0 | 1 | 6 | 1 |
| XIII-XIV | 12 | 7 | 6 | 6 | 0 | 0 | 0 |
| XV | 6 | 7 | 6 | 6 | 0 | 0 | 6 |

NOTE: The number of the MRE Version refers to the date of production, starting in 1980. For example, MRE V was produced in 1985; MRE XIV will be produced in 1994. All beverages are found in dehydrated form. Bev base, beverage base, a fruit-flavored powder available in cherry, grape, orange, and lemon-lime flavors. SEP, Soldier Enhancement Program, an accelerated product development program. Items tested in the SEP were evaluated for possible inclusion in future MREs.

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TABLE 12-2 Nutrient Composition of Meal, Ready-to-Eat (MRE) Beverages

| Beverage | Kcal | Protein (g) | Carbohydrate (g) | Fat (g) |
|---|---|---|---|---|
| Dairy shakes | 465 | 18.00 | 54.90 | 19.30 |
| Apple cider | 202 | 0.09 | 49.10 | 0.56 |
| Cocoa | 192 | 2.80 | 26.69 | 6.95 |
| Bev base | 150 | 2.48 | 28.19 | 2.99 |
| Tea | 116 | 0.15 | 26.80 | 0.86 |
| Coffee | 9 | 0.00 | 2.19 | 0.00 |
| Sugar-free bev base | 4 | 0.00 | 1.00 | 0.00 |

NOTE: All beverages are found in dehydrated form. Bev base, beverage base, a fruit-flavored powder available in cherry, grape, orange, and lemon-lime flavors.

In the studies in which soldiers were consuming an early version of the MRE—the MRE IV (Engell et al., 1987; Hirsch et al., 1985; Popper et al., 1987)—beverage consumption accounted for 178 to 274 kcal, representing 8 to 10 percent of the overall daily energy intake. With the addition of flavored fruit drinks to the MRE, the caloric contribution of beverages to overall consumption increased considerably. In all of the studies in which troops were consuming the Improved MRE, MRE VII, or MRE VIII (Lester et al., 1989, 1993; Popper et al., 1987), beverage consumption contributed 15 to 17 percent of the calories consumed in 1 day. Comparatively, Block et al. (1985) have found that nonalcoholic beverage consumption contributes about 15 percent of the calories consumed in the typical American diet.

The one exception to the 15–17 percent contribution of beverages to caloric intake in the field when the MRE VIII was consumed occurred in a cold weather study. Troops in one of three experimental groups consuming the MRE VIII (Lester et al., 1989) consumed only 13 percent of their daily intake in the form of beverages. In this study, each group was given a different heating device to heat their ration and water for beverages. In the two groups that reported they could heat water relatively easily, hot drink (coffee and cocoa) consumption was 181 and 187 kcal/d, but in the group that considered the process of heating water to be more difficult, hot drink consumption contributed only 52 kcal to daily energy intake. The results indicate that the relatively reduced intake of beverage calories was due to the limited consumption of hot cocoa in these studies with male soldiers.

In one of the most recently conducted MRE studies (Lester et al., 1993), 539 kcal were contributed by SEP MRE beverages, representing 20 percent of

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the daily caloric intake. This is a significant contribution because hot cocoa was not part of this ration prototype, and hot cocoa has contributed significantly to overall caloric intake in previous comparable studies. The chocolate, vanilla, and strawberry shakes found in this version of the SEP MRE contributed 69 percent of these 539 kcal and were a good source of protein, fat, and calcium, in addition to the carbohydrate which is the primary nutrient found in most of the other MRE beverages. Although the shakes received very good acceptance ratings in the field and their consumption contributed significantly to caloric intake, the inclusion of the shakes in future versions of the MRE is not planned at this time.

Analyses of the data on energy intake indicate (with one exception: Popper et al., 1987) that as the number of beverages in the MRE increased, soldiers chose to drink them and thus more beverage calories were consumed (Figure 12-1). Although this finding appears to be an improvement in terms of increasing daily caloric intake in the field, it could only be considered a real enhancement if the additional calories represent an incremental increase in overall daily intake and do not displace calories ingested in other forms. The calories ingested as drinks have been in fact found to be a true increment in daily caloric consumption, because consumption rates of the other ration

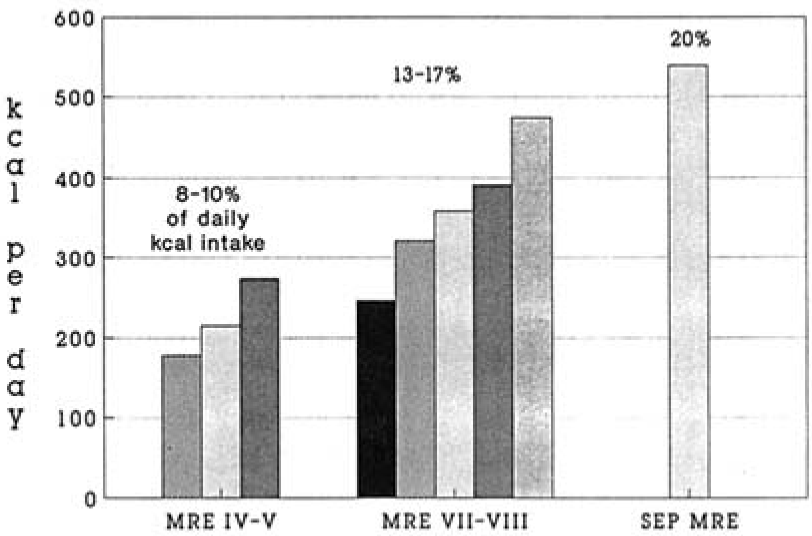


**FIGURE 12-1**
Energy intake (kcal) from beverages in Meal. Ready-to-Eat (MRE) IV-VIII field studies.
Roman numerals IV-VIII refer to production dates starting in 1980.
For example, MRE V was produced in 1985. SEP, Soldier Enhancement Program, an accelerated ration development program. Each bar represents data from at least 40 male soldiers consuming the ration for at least 1 week.

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components (e.g., entrees, starches, spreads, cakes) are not significantly different.

The most striking example from military field studies to illustrate that beverage calories add to total caloric intake is the author's 1983 study conducted at Fort Benning (unpublished data, 1983). In this study, beverage intake of soldiers receiving flavored, caloric beverages was compared to intake of soldiers who received only water. Although caloric intake from solid food (B Rations) was the same in the beverage conditions, the soldiers who received the flavored beverage consumed 1,050 kcal more each day than the soldiers who had only water to drink. The contribution of beverage calories to overall caloric intake has also been shown in other studies (Booth, 1988; de Castro, 1993; Rolls et al., 1990; Tordoff and Alleva, 1990).

## EFFECTS OF WATER AVAILABILITY AND HYDRATION STATUS ON FOOD INTAKE

In addition to making a direct, positive contribution to energy intake, the amount of fluid consumed can also have an indirect effect on caloric intake. The first to note that limited fluid intake led to reduced appetite and solid food intake were Adolph and Wills (1947). In one experiment conducted in the California desert, the effects of exercise-induced hypohydration on food intake were studied. Eight men were served a K Ration lunch either (1) after a 1-h walk, (2) following a 3-h walk, or (3) on a control day without exercise. Most studies addressing the effects of limited fluid intake on food intake in humans, including this study, have resorted to measures like rapid body weight loss or urine-specific gravity to assess hydration status. Although there are more precise indices of hypohydration, research indicates that rapid body weight loss or urine-specific gravity levels can be used to indicate hypohydration (Francesconi et al., 1987).

The results of the Adolph and Wills study (1947) showed that after walking in the desert for either 1 or 3 hours, the men lost about 2 percent of their body weight. When offered lunch with 100–700 g of water, they reduced their food consumption (Figure 12-2). This study suggested that hypohydration causes a reduction in voluntary food intake. However, as Adolph and Wills pointed out, the interpretation of the 1947 study is somewhat limited because the experimental design was not balanced. In addition, information relating the amount of water intake to food consumed by individuals during the meal was not provided. This shortcoming limits interpretation because it is not known if hypohydration or the amount of drinking at the meal affected food consumption.

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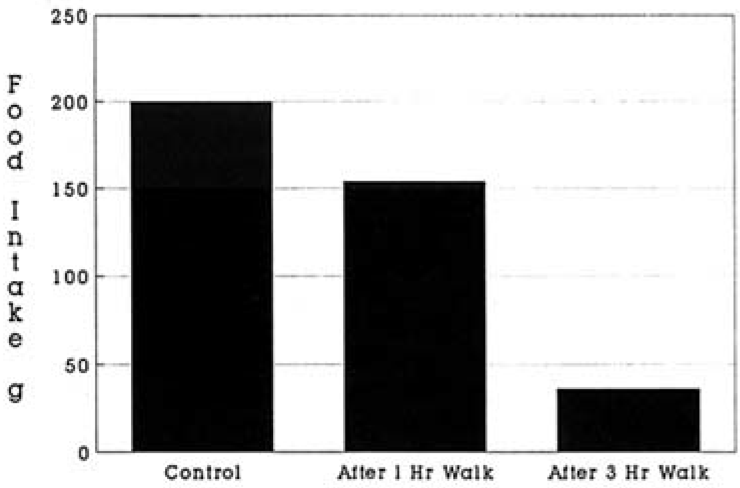


**FIGURE 12-2**
Effect of heat- and exercise-induced hypohydration on food consumption. After a 1-h walk, subjects lost 1.8 percent of their body weight; after 3 hours, 2.3 percent of their body weight was lost.
SOURCE: Data from Adolph and Wills (1947).

Several years ago this author began to explore the effects of limited water intake on food consumption (Engell, 1988). In a repeated measures design experiment, 17 soldiers (all men) were assigned to two conditions, ad-libitum water and restricted water, for 2 days. On each of these 2-d trials, subjects alternated between ad-libitum and restricted water intake conditions. When subjects were in the ad-libitum condition they could drink as much as they wanted between and with meals; when in the restricted condition, they were allowed only 8 oz (0.24 L) of water with their meals and nothing to drink between meals, which corresponded to 40 percent of the water consumed in the ad-libitum condition. Food intake (which consisted of MRE rations supplemented with commercial foods provided by the experiment) was ad libitum in both conditions. Scales measuring hunger, thirst, loss of appetite, and fullness were completed before and after each meal.

By the end of the 2-d period, subjects lost about 2 percent of their body weight when in the restricted water intake condition, a loss similar to that observed in the Adolph et al. (1947) study. The results, which are consistent with those of Adolph and Wills (1947) and Bass et al. (1955), show that inadequate water intake leads to a significant reduction in food intake (Figure 12-3). A significant negative correlation between subjects' thirst ratings and

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food intake was found ($r$ = -0.47; $P$ <0.05); in addition, a significant positive correlation between thirst ratings and loss of appetite ratings was observed ($r$ = 0.52; $P$ <0.05). Although this experiment demonstrated that limited water intake reduces food consumption and that thirst is negatively correlated with food intake, the question of whether hypohydration or limited water availability during a meal is responsible for the reduced food intake was not resolved.

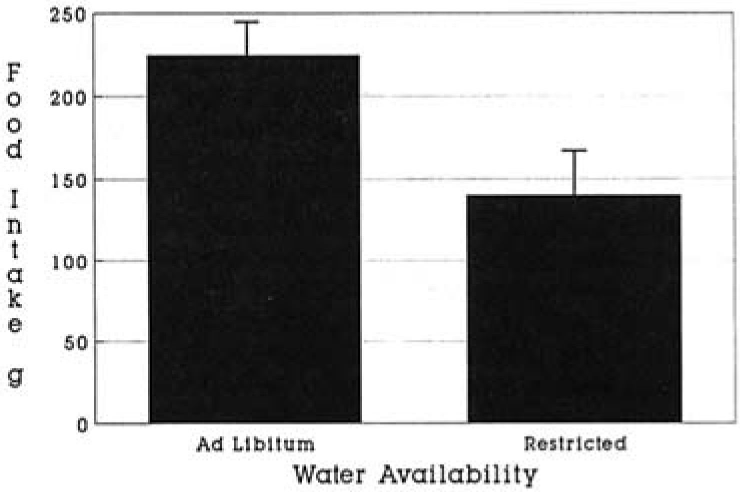


**FIGURE 12-3**
Effect of limited water availability of food intake.
Subjects in the restricted water intake group lost approximately 2 percent of their body weight. Figure shows voluntary reduction in food intake. SOURCE: Adapted from Engell (1988).

The next experiment addressed the question of whether the amount of drinking water at one meal affects food consumption (Engell, 1993). Soldiers who had not been deprived of food or water were served an ad-libitum lunch on 5 separate days. On the first day, water intake was ad libitum. On the following test days, subjects were given either no water or 25 percent, 50 percent, or 75 percent of average ad-libitum consumption. Premeal ratings of thirst were the same in all groups; however, by the end of the meal, the thirst ratings were elevated in the groups with limited available water. Results indicated that despite differences in thirst levels and different amounts of water available with the meal, average food intake in the five experimental conditions was not affected. Rolls et al. (1990) also found that food consumption was not affected by limiting beverage intake during a meal.

Results from these studies (Engell, 1993; Rolls et al., 1990) demonstrate that peripheral thirst sensations are not solely responsible for reduced food

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intake and that the lubricating effects of water are not essential to maintain normal levels of food consumption during one meal. The desire for lubrication was, however, suggested in the Engell (1993) study. The amount of water available did not affect the intake of even the driest foods, such as granola bars and cookies, but it did affect the intake of condiments, such as mayonnaise and mustard. The intake of these lubricating items was larger in the groups that had the least amount of water available with their meal.

In another study germane to this discussion of the effects of water availability and hypohydration on food consumption, Engell (1993) investigated the effects of water temperature on water intake. Subjects were assigned to one of three groups that varied according to drinking water temperature ($40^1$, $72^1$, $103^1$F [$4.4^1$, $22.2^1$, $39.4^1$C]). Water was available during a 6-h period of walk/rest cycles in a $103^1$F ($39.4^1$C) chamber prior to an ad-libitum MRE meal. As expected, subjects consumed more of the cooler beverages, resulting in a range of hydration levels. As in the previously reported study, the amount of water consumed at lunch did not affect the amount of food consumed. However, a significant correlation between hypohydration (as indicated by rapid body weight loss) and food intake was found: the more hypohydrated the individual, the smaller the quantity of food consumed.

The results of the studies reviewed in this section indicate that hypohydration rather than peripheral thirst sensations is probably responsible for the voluntary reduction of food intake associated with limited water consumption. Elevated thirst is not associated with reduced food consumption unless it is associated with hypohydration (as indicated by rapid body weight loss or elevated urine-specific gravity). It is possible, however, that when individuals expect an extended period of limited beverage consumption, food consumption may be reduced even if hypohydration is not yet evident. This possibility, which suggests that learning or experience with hypohydration may affect food intake, has not been investigated. Although the role of experiential factors in fluid intake in animals has received some attention (Fitzsimons and Le Magnen, 1969; Holland, 1991), the role of learning in human fluid intake has not been studied directly.

Does the research just reviewed elucidate the reasons for the inadequate ration consumption observed in military field settings? Laboratory and field studies have demonstrated that hypohydration leads to reduced food intake, and hypohydration (as indicated by elevated urine-specific gravity levels) has been observed repeatedly in field studies (Edwards et al., 1989; Francesconi et al., 1987; Popper et al., 1987; Salter et al., 1991).

It is important to note that when measures of hydration status (e.g., mean urine-specific gravity) are reported to be normal, a significant number of men may be hypohydrated on several days during a field exercise. For example, the average urine-specific gravity levels were 1.0238 and 1.0233 in a recent field

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study (Salter et al., 1991), but 20 to 25 percent of the men on several days had urine-specific gravity levels at or exceeding 1.030, which is indicative of hypohydration (Francesconi et al., 1987). Similarly, in the Popper et al. study (1987), the mean urine-specific gravity level for each group was below 1.03, but on most of the test days there was at least one group in which 25 percent of the men had urine-specific gravity levels above 1.03.

Although current evidence suggests that hypohydration could be one of the contributors to inadequate food consumption in the field, no analytical studies have been completed to assess directly the effects of hydration status on food intake in the field. Additional analyses on existing data bases and additional research are required to answer the question properly. For example, using the existing data bases to assess the effects of hydration status on food intake using individual's data may clarify the question.

## FACTORS AFFECTING FLUID INTAKE DURING MILITARY FIELD EXERCISES

Hypohydration occurs in the field not only in extreme environments where climatic conditions place extraordinary demands on fluid balance, but also in temperate climates where water needs are moderate (Hirsch et al., 1985; Popper et al., 1987; Salter et al., 1991). The incidence of hypohydration in temperate environments where rates of water loss are relatively low suggests that there are conditions in the field that limit fluid intake. This supposition was addressed in one of the author's studies that demonstrated that beverage intake was higher in garrison than in field conditions when the same MRE ration was available (F. M. Kramer and D. Engell, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1990).

In this study, MRE foods and beverages were served either in a comfortable garrison setting or under typical field conditions. When the intake data were analyzed to determine what MRE components contributed to the increase of 1,000 kcal observed in garrison, it was found that beverage and dessert consumption was higher in garrison, and intake of all other ration components was the same in both conditions (Figure 12-4). Although the explanation for the difference in beverage consumption requires further study, one possibility is that soldiers drank more in garrison than in the field because beverages are easier to consume. In the field, beverage consumption requires more effort: soldiers need to prepare beverages and are required to wash their canteen cups following use. The effects of environmental influences (e.g., beverage accessibility) and sensory factors (e.g., flavor) on beverage intake will be briefly reviewed below.

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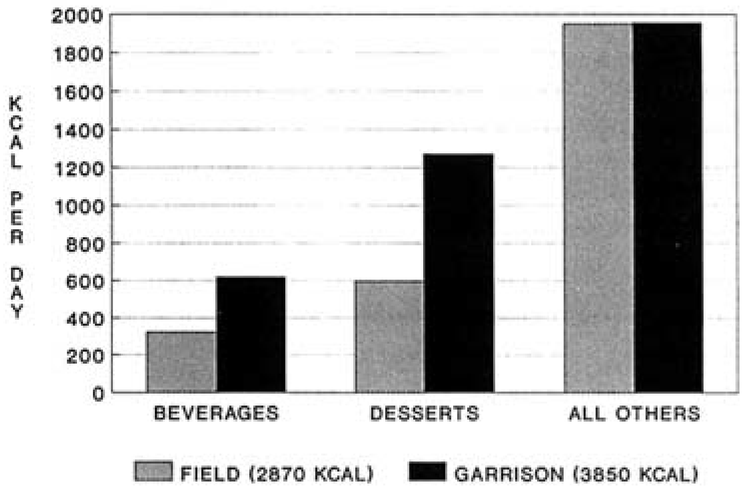


**FIGURE 12-4**
Food and beverage consumption of the Meal, Ready-to-Eat (MRE) in field and garrison conditions. Beverages and dessert intake account for the 1,000 kcal difference in consumption; all other ration components were consumed similarly in field and garrison conditions.
SOURCE: F. M. Kramer and D. Engell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1990).

### The Influence of the Drinking Environment on Fluid Intake

Beverage accessibility, when defined as the amount of effort required to obtain drinking water at a meal, has been studied in humans in two experiments (Engell and Hirsch, 1991; Engell et al., 1993). When the amount of effort required to obtain water is minimally increased from that expected in a meal setting (i.e., when it is moved off the dining table), individuals reduce their drinking significantly. For example, Figure 12-5 shows that when the drinking water was moved from a dining table to only 20 ft (6.1 m) away, drinking was reduced by 56 percent; moving the water further away from the subjects than 20 ft had no additional effect.

The effect of beverage accessibility over a longer period of time would be of interest when considering fluid intake levels in field settings, but there are no data available. However, data related to soldiers' perceptions of how convenient it is to refill their canteens in the field are available. In a recently conducted survey, 615 soldiers who had participated in field training exercises

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in diverse environments (e.g., Panama, Korea, New Jersey, Florida) were asked about their beverage preferences, consumption rates, and other issues related to their drinking habits in the field and at home (D. Engell, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1994). When requested to rate how convenient it was to obtain water in the field, only 52 percent of the soldiers said that obtaining water was convenient, which suggests that water intake in the field could be limited by the amount of effort required to refill canteens.

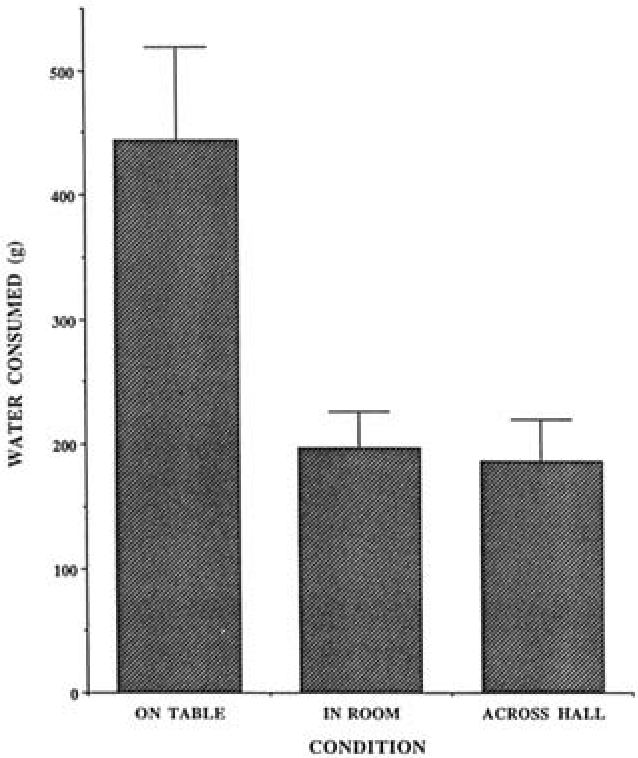


**FIGURE 12-5**
Effect of effort to obtain water during a meal on water intake.
The water was either on the table, approximately 20 ft (6.1 m) across the room, or approximately 40 ft (12.2 m) across the hall.
SOURCE: Adapted from Hirsch and Kramer (1993).

Another influential factor affecting fluid intake is food availability. About 70 percent of all normal fluid intake in humans occurs at mealtimes (see de Castro, 1988; Engell, 1988; Phillips et al., 1984). Food-associated drinking

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may be mediated by actual or anticipated physiological changes brought on by food consumption, as suggested by Kraly (1991). Alternatively, environmental factors, such as the relative ease of beverage accessibility at mealtimes, or social factors may be responsible for this pattern of normal fluid intake.

The social environment in which soldiers eat and drink could also affect the amount of beverage consumed in the field. Several studies have shown that social models and social facilitation influence food intake (see de Castro, Chapter 20 in this volume). However, information on the impact of a social model on nonalcoholic beverage consumption is considerably more limited (Engell et al., 1993). In this recent study, groups of 20 male subjects were served a meal with drinking water, either alone or with a confederate who drank either a relatively small or large quantity of water. When the confederate drank a large amount of water, subjects consumed more water than when they were alone or with the confederate who drank a small amount of water [ $F(2,53) = 3.48$, $P < 0.05$] (Figure 12-6).

### The Effects of Beverage Attributes on Fluid Intake

Beverage attributes have been shown to have powerful effects on consumption. Beverages with higher hedonic ratings are consumed more than those with lower ratings, and the flavor and temperature of beverages, as well

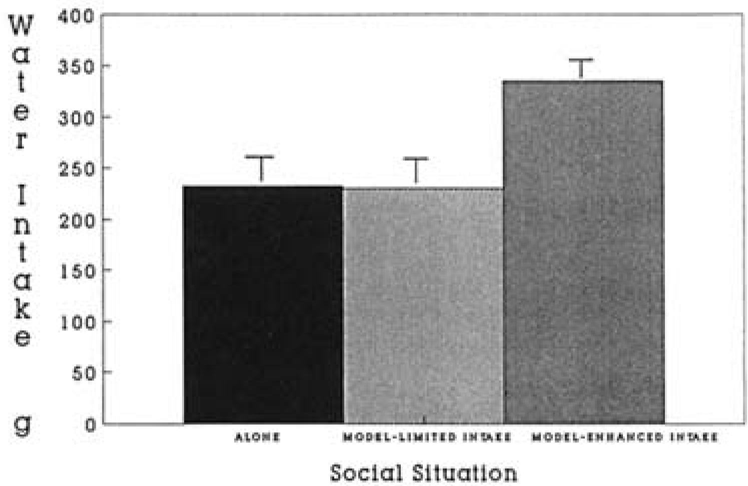


**FIGURE 12-6**
Effect of a social model on water intake during a meal [$F(2,53) = 3.48$, $P < 0.05$].
Figure shows intake of subjects eating and drinking either alone or with a confederate who consumed either a relatively small or large amount of water.

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as the amount of beverage variety, have been shown to affect the acceptance and amount consumed (see Engell and Hirsch [1991] for a review). The relative impact of environmental conditions (e.g., water accessibility, social factors) and beverage attributes (e.g., flavor, temperature) on beverage intake in the field have not been assessed.

Beverage appropriateness (see Schutz, Chapter 18 in this volume) or individuals' reasons for drinking beverages on particular occasions may also affect beverage choice and consumption. In the aforementioned survey of soldiers' beverage preferences and intake patterns (D. Engell, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1994), soldiers were asked to choose the primary reason for consuming the beverages found in rations. The "motivation profile" for the various beverages was found to be different. For example, the primary reason for drinking water was to quench thirst, whereas the primary reason for drinking milk was because of its nutritional benefits. Figure 12-7 shows the main reasons soldiers drink water and beverages found currently in rations.

## SUMMARY AND RECOMMENDATIONS

The direct and indirect contributions of beverage intake to caloric consumption in the field were discussed. The direct contribution of beverages to the energy intake of soldiers was found to be significant: beverages contribute as much as 20 percent to daily caloric intake in the field. The indirect influence of beverage consumption on caloric intake was also found to be significant. Studies demonstrating that hypohydration rather than elevated thirst or beverage availability at a meal limits food intake were reviewed. When individuals are slightly hypohydrated, as indicated by rapid body weight loss or elevated urine-specific gravity levels, they voluntarily reduce the amount of food they consume. It was argued that hypohydration could be at least partially responsible for the ration underconsumption observed in the field. Finally, a brief overview of the sensory and situational factors with the potential to affect beverage intake was presented to provide a foundation for recommendations for enhancing beverage intake in the field.

The following recommendations present ways to increase beverage consumption in the field. Most importantly, beverage consumption should been couraged to prevent hypohydration, which can lead to performance decrements and severe heat injuries. It is also important to optimize beverage consumption because drinking contributes significantly to overall caloric intake.

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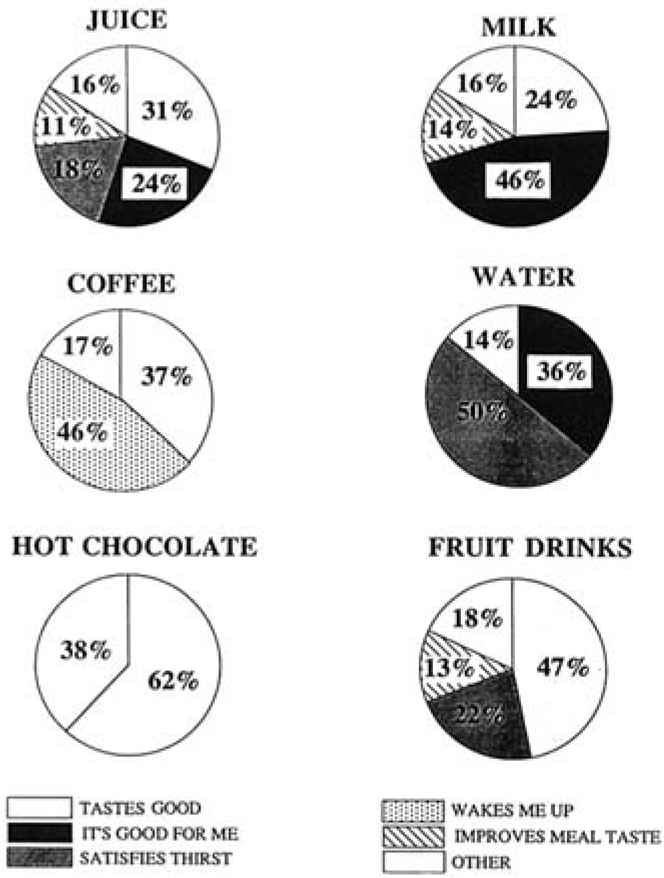


**FIGURE 12-7**
Primary reasons for consuming different beverages in the field.
Percentages represent the proportion of soldiers who were training in diverse environments. Soldiers completed an extensive questionnaire addressing beverage preferences, consumption patterns, and drinking habits in the field and in garrison.
SOURCE: D. Engell (U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., unpublished data, 1994).

### Recommendations Related to Ration Products

- Supplementing the rations with nutritionally-dense beverages should be considered. The excellent potential for increasing total caloric intake by using beverage supplements in the field is supported by research findings (Blair, 1991; Booth, 1988; Porikos and Van Itallie, 1984)

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- Replacing the aspartame-sweetened drinks in the rations with higher calorie drinks could increase overall caloric intake in the field. Laboratory research has shown that caloric intake at a meal (Rolls et al., 1990) and over a longer period of time (Porikos and Van Itallie, 1984; Tordoff and Alleva, 1990) are significantly less when subjects are given aspartame-sweetened beverages than when caloric counterparts are consumed. Although some research has indicated that aspartame increases appetite and could increase daily caloric intake, this possibility has been dismissed (Renwick, 1994).
- Including more diverse beverage products also could increase caloric intake. Diversity is important because variety enhances consumption (Rolls et al., 1980; Engell and Hirsch, 1991) and because beverages are consumed at different times for different reasons (Figure 12-7).
- Adding new beverage products to the system also may enhance consumption or at least prevent monotony from reducing consumption. For example, in 1986 when the fruit beverages were first introduced into the MRE, 73 percent of them were consumed (Popper et al., 1987); however, in 1991 only 26 percent of these beverages in a similarly configured MRE were consumed by soldiers at the same field site (Lester et al., 1993). Future research should address how often beverages (and other ration items) need to be added and how varied or "new" they need to be in order to optimize consumption.
- Individuals who plan future ration configurations should continue to use consumer research data (preference and usage data) from focus groups, surveys, and field studies to make their decisions. For example, when considering beverage additions and substitutions, soldiers' preferences and past patterns of intake should be reviewed.
- Drinking water should be cooled in the field. Research has shown that the temperature of water and other beverages has a significant impact on the amount consumed (Boulze et al., 1983; Hubbard et al., 1984; Sandick et al., 1984). When soldiers were asked about the acceptance of the drinking water temperature on recent beverage questionnaire, 62 percent said the water was too warm. Methods of cooling water should be evaluated and, if necessary, an improved system should be implemented in the field.

## Recommendations Related to Situational Issues: The Field Environment

- Beverage intake may be enhanced by optimizing conditions in the field. For example, commanders should ensure that troops have adequate time for meals, because most of all normal drinking occurs at mealtimes (de Castro, 1988; Engell, 1988; Phillips et al., 1984). Troops who are hypohydrated also tend to replace their water deficits during mealtimes (Adolph et al., 1947; Szlyk et al., 1990).

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- The water distribution system should be evaluated and improved, if necessary, to make water more convenient to obtain. Research has shown that increasing the amount of effort required to obtain drinking water reduces consumption (Engell and Hirsch, 1991; Engell et al., 1993), and about 50 percent of 615 troops recently surveyed described the location of their water supply in the field as less than convenient.
- Reducing the effort required to prepare beverages may also increase beverage consumption rates. It is also possible that soldiers avoid preparing beverage bases because of the time, effort, or water demand associated with washing the canteen cup. The use of a disposable cup, for example, could be considered.
- Officers and noncommissioned officers (NCOs) may consider drinking copiously in the presence of their troops, because it has been shown that social models can increase the amount that individuals drink (Engell et al., 1993). Although the effects of a model on beverage intake in a military setting have not been shown, the impact of the presence of a NCO on food intake has been demonstrated (Engell et al., 1990).

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## DISCUSSION

BARBARA ROLLS: One thing people might be interested in was whether the same number of calories in a liquid or solid form would have different effects on satiety. There's been one study, a French study, where Tournier and Louis-Sylvestre (1991) took a food and served it either as a soup or a pâté and found that the calories in a liquid form were less satiating. So more food was eaten following a solid than following the same number of calories as a liquid. Therefore, that's another potential way to increase intake. If you provide a very nutrient-dense drink, it perhaps will boost overall caloric intake. And that's what some of the supplements are.

Dianne, what do you think about David Booth's suggestion that a good way to increase calorie intake is to have drinks between meals? He says that drinks between meals slip in unregulated, and they're one of the major factors in obesity. If you can control those between-meal drinks and calories, you can keep intake down. Have you looked at timing of drinks at all?

DIANNE ENGELL: I've conducted one study that addressed the timing of adlibitum drinking (Engell, 1988). The results showed that about 70 percent of all drinking occurred at mealtimes, so it is quite possible that supplemental drinks would be consumed during meals and not between meals. The sensory characteristics of the beverage and its appropriateness for different uses would probably affect the timing of its consumption. Your point about "liquid calories" is interesting. I think that adding nutrient-dense beverages to the rations would be an excellent idea (regardless of when they would be consumed). Results from the Tournier and Louis-Sylvestre study (1991) and data from our field studies and your and others' laboratory work suggest that calories in beverages could increase caloric intake in the field.

JOHN DE CASTRO: What I found with the ad-libitum intake is that calories consumed in the form of liquids do not displace solid intake within meals and that most drinking occurs at mealtimes (de Castro, 1988, 1993). And it seems to be carbohydrate specific, going back to Barbara's point before. The carbohydrates just are not compensated for and you can sneak extra calories in that way quite easily.

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DIANNE ENGELL: That's consistent with what we have seen in our field studies. That is, it seems that calories from beverages do not displace calories from solid food.

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# 13

# Industry Approaches to Food Research

*Eileen G. Thompson*[1]

## INTRODUCTION

Research in the food industry is very different from academic research, both in terms of the total volume of research done and also the pace of the research. Most research in the food industry is designed around business decisions that must be made on some kind of timetable. Thus, the timetable of a decision largely determines the timetable of the corresponding research.

For example, at Quaker Oats each study is designed around a particular business decision. How can a product be optimized? Should a new product be introduced, or should an old product continue? What new food ideas are desired by consumers? A fair amount of packaging research is also done, because packaging is the consumer contact point with a food product.

As a result, industry does not really check hypotheses in the classic way that academic research does. As product after product and concept after concept is tested in industry, some generalities begin to emerge. These

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generalities may influence a change in methodology or a change in approach, simply because industry always wants to optimize its research process.

Another feature of food industry research is the constant inflow of validation data. For example, after determining an optimal product and using complicated models to predict sales of, say, $45.6 million, researchers begin tracking the sales data that come in every week. These data are used by researchers to evaluate their initial prediction.

## FOOD INDUSTRY FINDINGS

What follow below are generalizations that researchers at Quaker Oats have developed over many years of testing across a sequence of studies.

### Consumer Acceptance

One of the measures used widely in food research is consumer acceptance testing, often in the form of 9-point acceptability or "liking" scales. However, researchers at Quaker Oats have found that liking is a multivariate, not a univariate, problem.

For example, the Quaker instant oats products have a number of flavors. If Quaker Oats always marketed the best-liked product from among those tested, every product on the shelf would be some combination of apple-cinnamon-raisin because that is the most universally liked flavor for sweet breakfast goods. Therefore at Quaker Oats, one of the things that researchers ask is: How can multiple products be introduced that satisfy the largest population, even though some of the products may not score high in terms of "liking". Multivariate approaches are used to answer the question. When a line of frozen sandwich products was created, factor analyses revealed a segment of the population with a red meat preference. There was also a group of people who wanted products with lots of vegetables and another who wanted barbecue and other spicy flavors. Researchers responded by choosing one or two products from each of the factors so that the broadest product acceptance across the total product line could be achieved. Quaker Oats researchers have also developed an analysis technique that operates almost as a Venn diagram. It finds the combination of products that optimizes overall line penetration.

### Food Behavior

Another key finding from the food industry is that basic food behavior is difficult to change, and slow to change when it does. For example, when Quaker Oats tests a product, subjects are asked: What would you substitute

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this product for? If subjects cannot think of what they would substitute the product for and say, "Oh well, I am just going to add it to what I do now," there is a real danger. Although there are products that come along that actually change people's eating behavior patterns, it happens rarely. One example of a product that changed food behavior is bagels. Bagels have taken over, and everybody is building bagel factories. Bagels are an ethnic food that have come into wide acceptance because people have found new ways to use them (as sandwiches for example) and have changed their behavior to incorporate them into their eating patterns. In general, however, the idea that a new product will change people's basic patterns of relating to food is not very likely to lead to success.

## How Free-Ranging Consumers Eat

Food researchers need to have enormous in-depth insight into how free-ranging consumers eat. When people do not know that they are being observed (via unobtrusive observation techniques), just what do they eat? If information is desired on caloric intake for young male soldiers, then young men in a variety of heavy work exercise environments outside the military should be observed. Anthropologists can be used as observers when there are behaviors that are not quite understood.

If a comparison of caloric intake between garrison soldiers and soldiers in the field is desired, the following would be a suggested approach. Develop a comparable sample of young civilian men who are engaged in various kinds of heavy work activity, but who have no constraints on their eating. For example, find a construction company during the summer that would cooperate and allow anthropologists on the job site to watch what the young people who are building houses eat and how they divide their calories. Then ask the following questions: What proportion of the total calories are coming from beverages? What proportion of the total calories are coming from snacks? How do subjects eat those snacks?

One of the patterns observed in research at Quaker Oats with regard to snacking is what has been called "mindless nibbling." People often eat while engaged in other activities, and the repetitive crunch-taste-crunch pattern of snacking results in a much higher calorie intake than the person may realize. Civilians involved in heavy work activity may take in a fairly high proportion of calories in this manner.

Some beverages can also boost calorie intake, as can supplementary snacking alternatives. For example, in the cereal industry, some products that are being marketed are actually cereal, but they are designed to be hand-held snacks. Perhaps for military personnel there is a product that soldiers could carry with them, so that they could do the mindless nibbling while working at

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something else. This might help alleviate the problem of stopping to eat in the field.

## Observation Techniques

It is important for food researchers to be as innovative as possible in the area of unobtrusive observation. Obtaining a large sample size is not what is important. Rather, it is important to vary the nature of the studies. For example, a particular study might provide insight into a problem, even though the sample size (*N*) is small. Then the next study would verify and quantify the findings in a more controlled form of testing. It is important to spend more time and resources in the hypothesis development process and less on the verification.

At Quaker Oats, researchers have found various ways to hide video cameras, send anthropologists out to do in-home observation, and perform instore observations. A good example of the necessity for unobtrusive observation comes from the Quaker Oats home mix product line, which includes a variety of pancake and cornbread mixes. What researchers have found is that whenever in-home product evaluation is done, where respondents are given a box of products with instructions on the box, they follow the instructions quite accurately. In real life, however, almost no one measures precisely when making pancakes. To get people to behave the way they usually do, the observation must be designed so that testing is not the primary focus of the subject.

Quaker Oats researchers have also benefitted from unobtrusive observation in the form of video study in the pet food aisle. Researchers were trying to learn how much time people spend looking at the various products. How many of the products do they examine? Do they only go to their one brand? What was found in the area of pet treats was totally unexpected. Observers saw children accompanying their mother, and while mother was grabbing the big bag of dog food, a child said, "Wait, wait, wait, get him a treat!" The children actually climbed up the shelves because the pet treats were on top. This led Quaker Oats to reevaluate the role of children in the purchase process. In this case, observation revealed some important information on who influenced the purchase and better shelf location for the product.

## Food Research and Physiology

Food researchers also need to consider physiology. Not only is nutrition knowledge needed, but the science of aroma, taste, and craving must also be investigated. For example, in the food industry, microwave products have been less successful than was expected. Products that were meant simply to be

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heated in the microwave have not done well; sales have not increased as predicted. What appears to be happening is that microwaved foods produce different odors than when the same foods are baked or toasted. In the microwave, the chemicals produced actually create a burned smell and taste as opposed to the caramelized smell and taste when foods are baked or sauteed. Engineers have actually experimented with designing odors into the packaging so that when the product is cooking in the microwave, it produces more familiar cooking odors. There may be an opportunity here for the military to enhance odors in order to affect appetites.

In the area of cravings and taste preferences, researchers at Quaker Oats who are testing some products have found that exercise seems to affect taste perceptions. Sports beverages are only tested among people who are exercising at a health club or competing in a marathon. Considering the high exercise levels in the field situations, the initial testing of products should be done with people who are exercising. Even for a small test of, say, the variations of pineapple upside down cake, subjects should be recruited who are coming out of some kind of an exercise situation.

## Amount of Consumption

Another methodological issue that must be dealt with in product evaluation is how much product subjects actually eat in a test. For example, one test will give respondents multiple products, and they will be asked to take just a couple of bites of each. In another test subjects may be asked to eat all of a product, for example, a full bowl of cereal. Or subjects may be asked to eat an entire meal and then rate a product as part of that meal. Finally, an extended-use test may be conducted where respondents are asked to eat something day after day. Sometimes the same product will get different ratings across the methodologies. Thus if three different versions of a product are being compared, respondents may give a high rating when they just taste a taste, but they may give a different rating when they eat it 5 days in a row.

In a small-quantity testing situation, probably the optimal product is a candy bar, because the sweeter it is, the fattier it is, the richer it is, the better one bite of it tastes. However, if that same candy bar must be eaten day after day, the sweetness could become cloying. Therefore, a less sweet product may actually be optimal. At Quaker Oats, one sweet, fruit-flavored product was considered optimal based on ratings in the small-quantity testing situation. An absolutely top-notch taste rating was obtained. Yet when the product was developed to the point where people were given it in full-size servings, the consumers did not finish it. Thus the taste of the product was optimized in theory, but the product had not been optimized for the amount actually consumed in a normal setting.

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## Packaging

Packaging is absolutely critical for the development of food products, because it can encourage or deter consumption. For example, an employer was worried about the weight gain of his employees. A coffee cart passed through the building every day, and it had a small red awning with little bells hanging from it. All of these details were removed, and the cart was painted battle-ship grey, with the result that sales from the cart decreased by 40 percent.

Another example is the a problem with one new product concept at Quaker Oats. Researchers were working on a whole line of chicken sandwiches and hamburgers. The product idea was one of high variety, including a barbecue flavor, a mushroom-onion flavor, and a guacamole flavor. The picture of the guacamole product on the photo shown to consumers, which showed "green goo" on the chicken sandwich ruined the entire concept for the testers. Consumers disliked everything about the concept. They disliked all the flavors because the guacamole picture was so unattractive that it turned them against the entire line. Thus the military should address the packaging problem with current technology. Camouflage is important for packaging, but much variety can be designed even with the two colors of beige and brown.

The name of products is also important, and what they are called makes a difference in consumption. For example, one product with the same flavoring could be called "apple cinnamon," "apple crisp," or "baked apple." The new product would be tested under each flavor name to determine which name is more appealing and consumer perceptions of how the product tastes. A restarateur known by the author has found that she can manipulate customer orders for dishes simply by the name she selects for the item.

## Seasonings

Complex seasonings—particularly in ethnic foods—have a growing role in American food preferences. In many cases, seasonings are replacing fat and salt as the key taste contributors. For example, salsa now has higher sales in the United States than does ketchup. Quaker researchers are finding that consumers like "hot" food. There are different ethnic-based types of seasonings, for example Cajun, Mexican, and Thai, and there appears to be consumer interest in all of these variations. Researchers at Quaker Oats have found that having personal seasoning control is optimal. The inclusion of hot sauce in military MREs is something that Quaker Oats data would support.

Herbs and spices are also becoming more important influences on American choices. Not only are corporate sales of herbs and spices on the rise, both for use in the home and in food service, but increasingly, products are named by an herb or a spice. Thus, one finds pasta with basil sauce or lemon thyme chicken and such products have high appeal for consumers. This interest

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in herbs and spices can help the military execute its plan to rotate meals and achieve up to 24 different varieties. For example, chicken breasts can be prepared in a myriad of ways, including Mexican chicken breast and Italian chicken breast. Both are quite appealing.

## CONCLUSION

When it comes to food, perception is reality. One of the problems in the food industry is that when a product runs into trouble, managers simply announce that in this particular area, consumers are being inconsistent. For example, consumers are labeled "inconsistent" because they have a salad for lunch and then have a chocolate dessert. In fact, what researchers have found, especially among young women, is that they are counting fat grams, and they treat fat grams almost as an allowance. If they can save 5 g of fat on their salad dressing and 3 g of fat by having nonfat yogurt, then by the end of the day, they can spend their allowance on chocolate ice cream. The ice cream provides more pleasure, and they end up with approximately the same amount of fat grams.

Thus, the behavior that is often labeled inconsistent may in fact be very rational and consistent. It is important when results appear to be inconsistent, to call in the video cameras and the anthropologists to try to find out what is really going on.

## DISCUSSION

CELIA ADOLPHI: Eileen, at one time I had heard numbers thrown around that the average product in the grocery store stays on the shelf for about 18 months and is replaced by another product. I don't know what the data show today, but products do in fact turn over. Do you see that having any impact on how we manipulate and manage our ration consumption?

EILEEN THOMPSON: Well, one of the things that is happening in the grocery industry is that there isn't enough room on the shelf, and so we run into problems. Recently a consumer was complaining about how our apple-cinnamon granola bar isn't available any more. It isn't that we don't want to make apple-cinnamon granola bars; it's that we wanted to make a new flavor of granola bar, and in order to get that on the shelf, we had to give something up. So I think it's sort of comparable to the situation: you really only have 12 MREs. If you can only have 12 MREs, then you're going to be in the situation of constantly having to replenish and change that set. If you can have 24 MREs, then the longevity of any one product may stay.

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The food industry also develops products very quickly to meet consumer-stated demand and then may not optimize that product. We tend to put the product on the shelf and in essence say, "Well, we will get it out here and then we will fix it. Consumers tend to have very little patience for that. If they try something and don't like it, that's really a problem.

RICHARD JANSEN: A comment about flavor in general is that (I think that Barbara Rolls' talk related to this) if you reduce the caloric density of the diet, the sheer volume will result in weight loss. But if you're talking about people that you do not want to lose weight, like we're talking about here, you've got a real problem with fat because fat in fact holds flavor on the tongue. It's not just whether fat is there or not, but the presence of fat causes the flavor to stay on the tongue longer and so when we are going to try to have this idea that we're going to meet all these health objectives, which are really irrelevant for short-term missions, and try to reduce fat at the same time, you've got to be very worried about flavor. I think that that's one reason why they're throwing away foods that are lower in flavor and lower in fat and eating those things that have better flavor.

EILEEN THOMPSON: As I said, I'm not a physiologist. I just wanted to raise the fact that I had heard of studies that actually show a distaste for fat in high exercise situations, such as marathons.

IRWIN TAUB: Your comment about the universal appeal of the apple-cinnamon-raisin flavor is very relevant to the design of let's say the 12-menu MRE taste. I take it you're trying to appeal not to just the large group who like the flavor, but also to other niches that have a liking for other flavors. That suggests to me that you produce your products for different groups of people who like different things, and you do not average the responses. This suggests that for an MRE, instead of just having one entree of each type—i.e., 12 in a case—you might have three of the high ranking one, two of the next ranking one, and at least one of all the others. In that way, no one has to really do without what they like and you still have greater consumption of that particular MRE case.

EILEEN THOMPSON: Yes, you need to take both things into account. There is a floor in "liking" scores, below which you can't go. Let's say we are testing 30 products. We wouldn't even look at the bottom 18 scores, but of the top scores, the four we choose might be 1, 2, 5, and 8 rather than 1, 2, 3, and 4. As I said, we've got a computer program that looks at all combinations and indicates which combination of four gives us the largest number of people who like something in the line.

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PRISILLA DOLLOFF-CRANE: Both in Barbara's presentation and the comments that were just made, there seems to be a drift toward going back to higher fat levels within the operational rations because of short-term utilization. Based on what we heard earlier, we're spending more of our lives out in the field in nonchoice environments. We are being exposed, especially on the younger troop level, to the knowledge that fat is bad, with the long-term chronic health problems and such. When you put a captured population in nonchoice environments, you are going to have angry people who distrust the system that is feeding them, who do not want to eat a high-fat diet. They know that high fat is bad, but they have no choice. They're spending a lot more than 2 weeks out there, and it's not short term. We are going out there for extended periods, 50–60 percent of our time, and it is totally wrong to go back to high fat. What we need to do is provide them with information that tells them they've got to consume the calories.

HERBERT MEISELMAN: As a follow up to Irwin Taub's point: I think it's important to keep in mind that our soldiers often don't have the chance to choose their meals. Thus, if food is available that they don't want, they may get stuck with it. For that reason, there of course hasn't been fish and liver in the MREs because many people aren't going to accept them. So I think the comparison to the commercial market is very different. Perhaps we should consider for the future that soldiers should be able to choose. I think it would solve many of these problems.

EILEEN THOMPSON: Yes, I would agree with that again. But when I say we don't just pick the top four, the eight from which we would choose would all have high acceptance scores. So we wouldn't be putting the fish and the liver in there, they would be down on the bottom.

PHILIP BRANDLER: When we've gone through some of our analyses in terms of which items to put into the MRE, it's ended up with three beef items were the top three, then the fourth one down was a chicken. We do a beef and a chicken because otherwise you end up with the problem of all beef items. So, we don't deal specifically with acceptance in the absence of any evaluation of whether or not the items fit together. If they're all three red-sauced pasta items, one is probably enough of those. So I think we've taken at least a nod at that without a complex computer program to back up our decision making.

STEPHEN PHINNEY: I hate to interject anecdotal information, but I'm not the first, so I will. I did a fair amount of endurance bicycling and I can tell you from multiple repeats of the same individual, myself, that when I would push out my training envelope too far, those couple days thereafter I have a high aversion to fat. Now, I eat a lot of fat. In fact there have been certain dietary circumstances where I've eaten probably more fat than most human

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beings have as a percentage of total calories, and I can do that. It's not that I distaste it or avoid it. But under unusual physical stress conditions, for instance if I trained up to 60 miles, then I go and do a 100-mi ride and the last 20 miles someone comes along and I try to keep up. For the next couple days, I'm probably going to be eating soup and crackers and light carbohydrates. I just have an aversion to fat. So that might reinforce the comments you made. And it may be germane to when you take soldiers out of the garrison. If they exceed their training envelope, they may at least for a time have a similar problem in terms of avoidance of fatty foods.

GILBERT LEVEILLE: I just want to surface the issue, because I think it's very important that it be put in perspective. We may have a situation where the perception is as you stated and we're going to have angry people. But I think for both the civilian and military population, it's awfully important that we take the knowledge that's been accumulated over the last 30 or 40 years on fat and put it into perspective in terms of what components of fat are of a health concern from a chronic disease point of view. Fat per se from a caloric point of view, certainly in the civilian population, is a problem just in terms of caloric excess. But in the military population where you're trying to increase caloric intake, there aren't too many alternatives in order to achieve a calorically dense product. The question is what kind of fat do you use, and you probably need an educational program that gets around the fact that it's not fat per se but the kinds of fat.

RICHARD ATKINSON: This is the same for fat as not pouring out the baby with the bath water. In trying to get the field rations down to 30 percent fat, we have seen exactly the same thing that Gil Leveille's saying. You can't beat fat for caloric density. And yes you would like to go to 30 percent fat, or go lower in the garrison situation, but Steve Phinney, maybe you could comment on what happens to fat when you're in a high-exercise situation. I think exercise probably covers a multitude of sins. If they're exercising more, they're probably burning off that fat. If you eat a high-fat diet, it tends to put fat in the visceral depots, which is bad. However, when you exercise, that tends to mobilize the visceral depots. Steve, do you have any comments on fat and exercise?

STEPHEN PHINNEY: I would just say that if you're within your training envelope, and this has to do I think with lumberjacks and other people in high-stress situations, they're trained to that environment. They have reached a metastable state in that they don't exceed their envelope and therefore they can better utilize a mixed calorie diet. It sounds like a truism, but a well-trained soldier who is put to an assigned task will probably not have that much disturbance of caloric intake. However, if you take people from a relatively sedentary environment and put them into a high-activity environment, you

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have two factors. One is you've changed their environment, and the other is you've added an additional energy expenditure that traditionally people in most human studies, do not compensate for. Thus, you have exercise, which may have its own effects, and then an additional caloric deficit induced by the exercise per se. Keep them within their training envelope. You will probably do very well on what I would call a moderate-fat diet and that's the 30 to 40 percent range.

DAVID SCHNAKENBERG: We've looked at what happens to the serum cholesterol of soldiers out in the field with exercise, but it's kind of a confusing picture. We don't understand our customers. If you're in a situation where you could have a package ration system, the MRE, and we've had individuals lose 4 to 5 pounds in 10 to 12 days. Repeatedly we will see average serum cholesterol dropping say from an average of about 200 mg down to 180 or 185 in those 10 days. I suspect you could go to Pritikin's fat factory and they can't do any better…and we are cheaper.

If you look at the field ration tests in 1985, where we had many soldiers out in the field for 6 weeks eating different rations, our highest fat ration was our A Ration. It was about 40 percent of calories—not inordinately high. In this study the soldiers' body weight stayed relatively stable for the entire period. There were quite a few eggs offered in that menu and in that instance, serum cholesterol rose slightly on the average for the group over a 6-wk period. For those who were fed the packaged T Ration and one MRE, which had an overall low fat content of about 30 percent of calories, serum cholesterol actually went down. Karl Friedl will talk about another situation of severe caloric deprivation over extended periods of time in a range of studies where cholesterol levels had increased at the end of the studies.

KARL FRIEDL: They went from about 150 to 220.

EILEEN THOMPSON: So it's again a rather complex issue.

DAVID SCHNAKENBERG: Can I just clarify one point here? The point I was trying to make is that the situation that people are in and conflicts of their daily lives, like their exercise, not only affects the physiology, but it also may affect taste perceptions. If you're testing which ration does better among people who just sit around, you may not have the same kind of taste preferences that someone out there in that active environment will have.

JOHN VANDERVEEN: In that context, with the hot-weather testing that was done in a climatic chamber, people were working in the heat and then were offered beverages at various temperatures. The effect of a slight cooling of the beverage down to 70¹F had a dramatic impact in terms of volume of fluids actually consumed.

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WILLIAM BEISEL: I think the analysis that was made this morning in all of these studies is that the issue to consider maybe a low level of carbohydrates in the rations. We've got a long way to go in this meeting, and we're going to discuss a lot of things, but I think that we certainly are not low in terms of fat—that is, the proportion of fat and protein. However, the area of questions to me is carbohydrates. We need to come back to that and think a little bit more about that.

ROBERT NESHEIM: Ed Horton isn't here to defend himself, but at our last meeting he gave a whole presentation on metabolic events during exercise and he pointed out very clearly that the duration of exercise had a great deal to do with whether you were burning fat or carbohydrates. During the initial parts of exercise, it's primarily carbohydrates, and as exercise is protracted—as in marathoners or long-term bicyclers—after 30 minutes or so, you get up to using mostly fat as the source of energy. So we have to take exercise duration into consideration too.

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# Part IV

# Underconsumption and Performance

PART IV EXPLORES THE IMPLICATIONS of underconsumption for physical and cognitive performance. As presented in Chapters 14 and 15, research suggests that decrements in physical and cognitive performance do not begin until 10 percent or more of body weight is lost in well-hydrated individuals. Chapter 14 shows that the nature and duration of the physical performance, the performance tasks themselves, body composition at the time of testing, and rate of weight loss must be considered when assessing physical performance. The author reviews a number of physical performance tasks and situations that indicate decrements in physical performance are not evident with small degrees of weight loss or losses of body fat; rather, most evidence suggests that physical performance is maintained until weight loss approaches or exceeds 10 percent of initial weight.

The review of underconsumption and cognitive performance in Chapter 15 emphasizes methodological issues, such as establishing cognitive test standardization and reliability. Changes in cognitive performance can be attributed to underconsumption of rations, effects of the field setting, and adverse physical and emotional factors. Using fewer studies than those available to assess physical performance, the author finds that cognitive performance may be degraded when lowered energy intake leads to weight loss in excess of 10 percent of initial body weight.

In the final chapter of this section, the author uses data collected on athletes to show that caloric underconsumption has negative effects on lean body mass and physical performance. Energy deficits can be minimized with

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an adequate supply of protein, vitamins, and minerals and a minimal loss of lean body mass.

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# 14

# When Does Energy Deficit Affect Soldier Physical Performance?

*Karl E. Friedl*[1]

*During the last month of the siege men at fatigues, such as trench-digging, after ten minutes' work had to rest a while and go at it again; men on sentry-go would drop down from syncope (the spell of duty had to be reduced to one hour instead of two); those carrying loads would rest every hundred yards or so.*

Observations on the effects of restricted rations on British and Indian soldiers during the 1915–1916 Siege of Kut (Hehir, 1922, p. 867).

## INTRODUCTION

Several decades ago, Army nutritionists concluded that soldiers could maintain normal work capacity during short periods (< 10 days) of severely restricted intakes (Consolazio et al., 1967, 1979). This finding corroborated the conclusions from longer-term studies conducted at the University of Minnesota that an energy deficit resulting in less than 10 percent loss of body weight

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does not impair physical performance (Taylor et al., 1957). There is a long history of such Army-sponsored research on performance decrements related to energy-deficient diets that reaches back to laboratory studies from the University of Minnesota in the 1940s and 1950s (for review, see Grande, 1986) and field studies conducted by the U.S. Army Medical Research and Nutrition Laboratory in the 1960s and 1970s (for review, see Consolazio, 1983). In the past decade, the Occupational Physiology Division at the U.S. Army Research Institute of Environmental Medicine has repeatedly performed physical testing during ration studies (e.g., Askew et al., 1987; Moore et al., 1992; Teves et al., 1986). The data from these more recent studies have been largely overlooked because of the general absence of findings of performance decrements. These negative findings could be the result of protocols failing to produce an actual energy deficit or because the tests used were insensitive to real performance decrements. However, after these and other interpretations of the data are considered, the conclusion of this chapter will be that militarily relevant physical performance appears to be well sustained through the range of voluntarily low intakes (underconsumption) of modern military rations.

If underconsumption occurs for sufficient duration it will unquestionably produce deficits in physical performance. Changes in the oxidative capacity of muscle, the oxygen carrying capacity of the blood, and the mass of metabolically active tissue probably account for most of the observed decrease in aerobic capacity, which in turn, explains reduced stamina and physical work capacity (Keys et al., 1950; Spurr, 1986). Loss of skeletal muscle, changes in muscle biochemistry, and changes in the balance of muscle fiber types produce reductions in dynamic strength (Henriksson, 1990; Taylor et al., 1957). Such decrements in physical performance have been established at extreme levels of underconsumption in the 1950 Minnesota Starvation Study and in studies of soldiers in the U.S. Army Ranger course (Johnson et al., 1976; Moore et al., 1992 [Ranger I]; Shippee et al., 1994 [Ranger II]). These levels of underconsumption were voluntary only in the sense that the participants could quit the programs; if offered more food, these men would have readily consumed it. However, these studies are important for this book because they illustrate an extreme of underconsumption, which permits interpolation of the effects of the more pertinent (i.e., modest) energy deficits. A different militarily relevant extreme of underconsumption—very high deficits for a short period of time—will also be addressed.

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## ASSESSING UNDERCONSUMPTION

### Baseline Nutritional Status

A typical, fit, young male soldier weighs about 75 kg, and 15 percent of this weight is fat. These fat energy stores are adequate to fuel the soldier for a 1,000 kcal deficit per day lasting for about 75 days; beyond this point, energy deficits will be made up primarily from organ and muscle protein as the soldier enters an advanced stage of starvation. A certain proportion of lean mass, usually about one-third of the total weight change, is lost or gained along with changes in storage fat (Forbes, 1993), but as fat stores become increasingly scarce with a severe weight loss, this proportion increases. This was illustrated in the Ranger-I study (Moore et al., 1992) where an increased proportion of the lean tissue contributed to overall weight loss between 6 weeks (30 percent) and 8 weeks (40 percent). At the end of the 8-wk study, soldiers had lost an average 16 percent of body weight, and the majority of men were on the brink of a metabolic transition to severe starvation because they had little or no fat stores remaining (Friedl et al., 1994). This metabolic threshold also appeared to coincide with the approach of a psychological limit to voluntary participation, a point recognized by the Ranger Training Brigade commander by the number of soldiers who were disqualified near the end of the course for food violations (see Appendix 1 in Moore et al. [1992]). Thus, the paradigm of Ranger-I, a 1,200 kcal deficit per day for 60 days, appears to define an extreme limit of voluntary underconsumption for contemporary male soldiers.

Current-day soldiers can better tolerate an energy deficit (in terms of preserving performance) because they are better nourished and begin with more fat-free mass than the soldiers of earlier eras. This point is illustrated by a wartime example that involved apparently modest weight losses but resulted in profound physiological consequences. In the winter of 1915, 15,000 British and Indian soldiers were surrounded by Turkish troops at Kut in southern Mesopotamia; they surrendered when their rations were depleted 5 months later. By the time of surrender, intake for the British soldiers had been reduced to half of the estimated normal 3,600 kcal/d (Hehir, 1922). Weight loss averaged 10 and 14 percent of weights measured near the start of the siege for the British and Indian soldiers, respectively. Although these losses are not even as large as the relative weight loss observed in Ranger-I, the restriction had a greater impact on the average soldier than that observed in the Ranger studies. The chief medical officer recorded that "the present condition of the average officer and fighting man…is much below par in stamina, and, without feeling any decided weakness, he is incapable of doing anything approaching the

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normal amount of physical or mental work" (Hehir, 1922, p. 869). Numerous starvation deaths occurred before the surrender of the garrison.

The first point to be made from this example is that relative weight losses cannot be meaningfully compared unless the initial nutritional status is also considered. The soldiers at Kut were already at reduced weight from earlier fighting and a long march to Kut. More importantly, even at baseline, soldiers of this earlier era were not as well nourished as current-day soldiers. U.S. soldiers today have an average of 20 lb (9.1 kg) more body weight, including 15 lb (6.8 kg) more lean mass, than U.S. soldiers in World War I, and approximately 10 lb (4.5 kg) more than World War II soldiers (Friedl, 1992). A large loss of body weight (˜10 percent) in these soldiers with initially lower body fat stores and muscle mass could be a much more severe physiological challenge than it would be for typical modern-day, well-nourished soldiers. Consistent with this hypothesis, soldiers who began training with very low body fat (< 10 percent) in the Ranger-I study were less likely to succeed than were slightly fatter soldiers (Moore et al., 1992).

Current-day soldiers also receive nutrition of better quality than their earlier counterparts. The soldiers at Kut did not have a vegetarian Multi-Faith Meal (MFM), and at least 1,000 Indian soldiers who would not eat horseflesh were diagnosed with scurvy. They did not have rations carefully constructed to meet military recommended daily allowances (MRDAs) and to provide a balanced intake even in situations involving high stress and restricted intake. Many of the British soldiers suffered from beriberi with symptoms of degraded work ability superimposed on the problem of a deficient energy intake. These are problems that soldiers should no longer face. For example, in the recent Ranger studies, even in the face of a large average energy deficit over 2 months, no substantial vitamin, mineral, or nutrient deficiency could be established even when soldiers were subsisting on only one Meal, Ready-to-Eat (MRE) or one Long Life Ration Packet (LLRP) per day (up to 10 days continuously). Thus, comparisons to earlier studies must take into account the underlying baseline nutritional status.

## Overnourished Soldiers

Improvements in nutrition during this century have led to an increase in the proportion of overnourished soldiers. Thus, any study of the consequences of underconsumption must be carefully interpreted with respect to the number of soldiers who could well afford an energy deficit and particularly with respect to those soldiers who may be actively attempting to lose weight. In the 1991 study of the nutritional adequacy of the MRE compared to hot rations during field training, overweight men deliberately attempting to lose weight

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emerged as a significant confounding factor in the data analysis (Thomas et al., 1995). Fortunately, at the start of the study the investigators had asked who was trying to lose weight. One-third of the MRE test group was trying to lose weight and achieved a loss of 4.4 kg (4.8 percent of initial body weight; $n$ = 13), compared to 2.3 kg (or 3.1 percent weight loss; $n$ = 22) for the remainder of the group (Thomas et al., 1995). This weight loss was appropriate for men averaging a robust 26.5 ± 3.8 percent body fat[2] (compared to 18.2 ± 4.8 percent for the men not intending to lose weight). There was no indication from detailed nutritional and clinical serum biochemical tests that health or nutritional status was adversely affected with this weight loss, nor was there any indication that performance suffered (Thomas et al., 1995).

Another recent study investigated body composition changes in young female basic trainees eating without restriction (Westphal et al., 1995). This study revealed that at least one-fourth of the women exceeded Army body fat standards at the start of basic training. Despite an average intake of 2,600 kcal/d, this fattest group of women, averaging 36 ± 3.8 percent body fat[2], lost weight (0.5 ± 3.2 kg). However, the true magnitude of the body composition changes is overlooked if only reported as change in body weight; this group gained 1.7 ± 1.8 kg of fat-free mass at the same time they lost 2.2 ± 2.7 kg of fat (3 percent of body weight). Despite this loss of fat weight, the physical performance of these women was markedly improved at the end of basic training (Sharp et al., 1994; Westphal et al., 1994). This improved performance included an increased muscular endurance demonstrated by large improvements in push-up and sit-up ability, increased strength marked by an average increase of 10 lb (4.5 kg) in maximal lift capacity, and improved aerobic capacity indicated by an average 5-min reduction in 2-mi run times.

These recent studies of men (the MRE study) and women (the study of basic trainees) highlight the problems in evaluating the effect of field rations in modern-day overnourished soldiers. Voluntary underconsumption and/or some loss of fat weight in these subgroups are not necessarily harmful. There is even evidence that some aspects of physical performance will be improved. In an earlier Committee on Military Nutrition Research report, Kirk J. Cureton provided compelling evidence that the loss of excess fat weight can indeed enhance various types of physical performance, most notably run time (Cureton, 1992).

[2] Percent body fat in these studies was measured by whole body scan using duel-energy x-ray absorptiometry.

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## Nutritional Status of Female Soldiers

Although women have not been studied during extreme conditions such as those in the Minnesota Starvation Study or Ranger training, there is evidence to suggest that physical performance could be better maintained by female soldiers. This conclusion is based, in part, on a superior nutritional status in the form of larger gender-appropriate fat stores. A typical, young female soldier weighing 60 kg with 30 percent body fat carries sufficient storage fat to survive an energy deficit for approximately twice as long as her male counterpart. This hypothesis is corroborated by numerous wartime studies demonstrating the disproportionate survival of women over men during periods of extreme starvation (Brozek et al., 1946; Burger et al., 1948). Greater fat stores are only part of the advantage; at a comparable exercise level, women utilize fat energy better than men (Nygaard, 1985), and because of lower lean body mass relative to men, women have lower basal metabolic requirements.

Although female soldiers may hold a theoretical advantage during caloric restriction, and performance may improve rather than degrade with the loss of fat weight, underconsumption of rations produces a performance risk in women that is not encountered in men. Premenopausal women with restricted intakes are likely to encounter deficiencies of minerals and nutrients related to red cell formation (iron and folate). This increased potential for iron-deficiency anemia also leads to compromised work capacity (Finch and Huebers, 1982), as demonstrated by detailed studies performed on Sri Lankan tea leaf pickers (Edgerton et al., 1979; Gardner et al., 1977). In one study of these workers, all women with serum hemoglobin over 13 g/dl could complete an 18-min graded treadmill test, but fewer than half of the women with less than 12 g/dl could complete the same test (Gardner et al., 1977). The relationship between iron intake and performance was demonstrated with iron supplementation, where the effect could be calculated as a 0.75 kg increase in tea picked per day per gram of hemoglobin increase per dl of serum (Edgerton et al., 1979). Thus, work performance can be influenced by iron deficiency even within the clinically normal range for hemoglobin.

This problem of iron deficiency in women has direct relevance to U.S. servicewomen. Most recent studies of female soldiers indicate a large proportion of women to be only marginal for iron balance (King et al., 1993; Westphal et al., 1994). Inadequate intakes related to weight-loss attempts are responsible for at least some of this imbalance. In the 1989 West Point Nutritional Survey (Klicka et al., 1993), 80 percent of female cadets stated that they were attempting to lose weight. Measured nutrient intakes confirmed restricted caloric intakes, with at least 10 percent of cadets taking in less than 1,700 kcal/d (i.e., < 70 percent of the 2,400 kcal/d female MRDA for energy). Even when iron supplement use is included in the estimates, one-third of

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female cadets had iron intakes below the MRDA of 18 mg/d. One-third of the women sampled had hemoglobin levels of less than 12 g/dl of serum (Friedl et al., 1990), a point of diminished work capacity in the Sri Lankan women in Gardner et al.'s study (1977). The results of the West Point study suggest that women consuming less than 2,000 kcal/d at conventional nutrient densities may not take in sufficient iron and folacin to maintain optimal performance.

The effect of reduced hemoglobin (< 12 g/Dl) on performance has been recently demonstrated in young women in Army basic training. The women with lower hemoglobin concentrations had 2-mi run times that were 1 to 11/2 minutes slower than the others (Westphal et al., 1995).

Male cadets in the West Point study did not demonstrate problems with iron, and male soldiers do not develop signs of iron or other mineral deficiencies even during intensive training with reduced intakes observed in the Ranger course (iron intake averaged 13 mg/d over 2 months) (Moore et al., 1993). Thus, single nutrient deficiencies do not appear to be a concern in male soldiers, where the only compromise from restricted military rations is an energy deficiency.

## ASSESSING PERFORMANCE

### Work Capacity and Energy Expenditure

The importance of adequate intake to work productivity (i.e., voluntary energy expenditure) can be demonstrated when energy deficits are high or prolonged, specifically because additional calories will be readily consumed when offered, and productivity will increase (for extensive review, see Consolazio, 1983; Spurr, 1986, 1990). Thus, the circumstances are somewhat different from the problem of voluntary underconsumption. For example, coal and steel production in German factories during World War II fell off with the reduction in energy intakes as food supplies diminished, particularly when average intakes decreased from 2,200 kcal/d to 1,800 kcal/d (Consolazio, 1983). When the rations of a group of young coal miners increased from 2,800 to 3,200 kcal/d, production increased from 7 to 9.6 tons of coal per day per man; an additional 400 kcal/d produced a small additional increase in productivity (Kraut and Muller, 1946). Such studies suggest that voluntary work output can be limited by restricted daily intake.

Spurr has demonstrated an energy "ceiling" effect produced by chronic underconsumption. Using continuous heart rate monitoring, he showed lower average energy expenditures in undernourished Columbian boys mixed into a group of normal Columbian boys in a summer sports program. For several hours following a hot lunch, heart rates did not differ between the groups.

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However, after that time heart rates fell off in the undernourished group (Spurr and Reina, 1988). Although other factors such as mood and morale may contribute to these phenomena, the reduction in physical work capacity is most probably related to reduced energy stores, including low body fat and perhaps inadequately replenished muscle glycogen (Karlsson and Saltin, 1971).

Ranger students present a variation where a sustained physical effort is not optional, demonstrating behavioral and metabolic adaptations to accommodate the reduction in energy intake while maintaining the required level of effort. By the end of Ranger training, soldiers move with great deliberation and visibly demonstrate no wasted motion. There is also a marked reduction in circulating thyroid hormones and an increased sensitivity to cold, even in summer classes, which suggests the same reduction in cellular metabolism that has been measured in earlier studies such as the Minnesota study. Even Major General Sir Hehir (1922) demonstrated reduced body temperatures in his 1916 observations of semi-starved soldiers.

Results of increased feeding in this setting appear to be split between contributions to reducing the energy deficit (reducing the rate of catabolism of body energy stores) and increasing energy expenditure (raising the "ceiling"). In the Ranger-I study, energy expenditure estimated from changes in body composition and estimated intakes indicated an average energy deficit of 1,200 kcal/d and a total energy expenditure of 4,000 kcal/d (Moore et al., 1992). When the intakes were increased by 400 kcal/d in the Ranger-II study (Shippee et al., 1994), the deficit was reduced to 1,000 kcal/d, implying also an increase in energy expenditure to approximately 4,200 kcal/d (Figure 14-1A). However, the attenuated decline in triiodothyronine when the soldiers were given more food suggests that it was basal metabolic functions (e.g., body heat production) that were better sustained with the small increase in rations (Figure 14-1B). This result does not necessarily signify an increase in productive work.

After 24 weeks of semistarvation in the Minnesota study at nearly half of normal intakes, resting energy expenditure had declined by 40 percent. Although the majority of this decline was explained by the reduction in body cell mass, a portion of the reduction (15–25 percent) was attributed to reduced cellular energy requirements (Keys et al., 1950). In shorter-term studies, Grande et al. (1958) concluded that most of a decrease in resting metabolic rate was due to the decline in cellular metabolic rate, with no more than one-third of the decrease accounted for by loss of cell mass. An even greater savings in energy expenditure (accounting for approximately 1,000 kcal/d) in the Minnesota Starvation Study came from reductions in voluntary activity. These studies suggest several mechanisms, such as increased economy of movement and decreased resting metabolic rates, through which soldiers who are voluntarily underconsuming might demonstrate a reduction in energy expenditure

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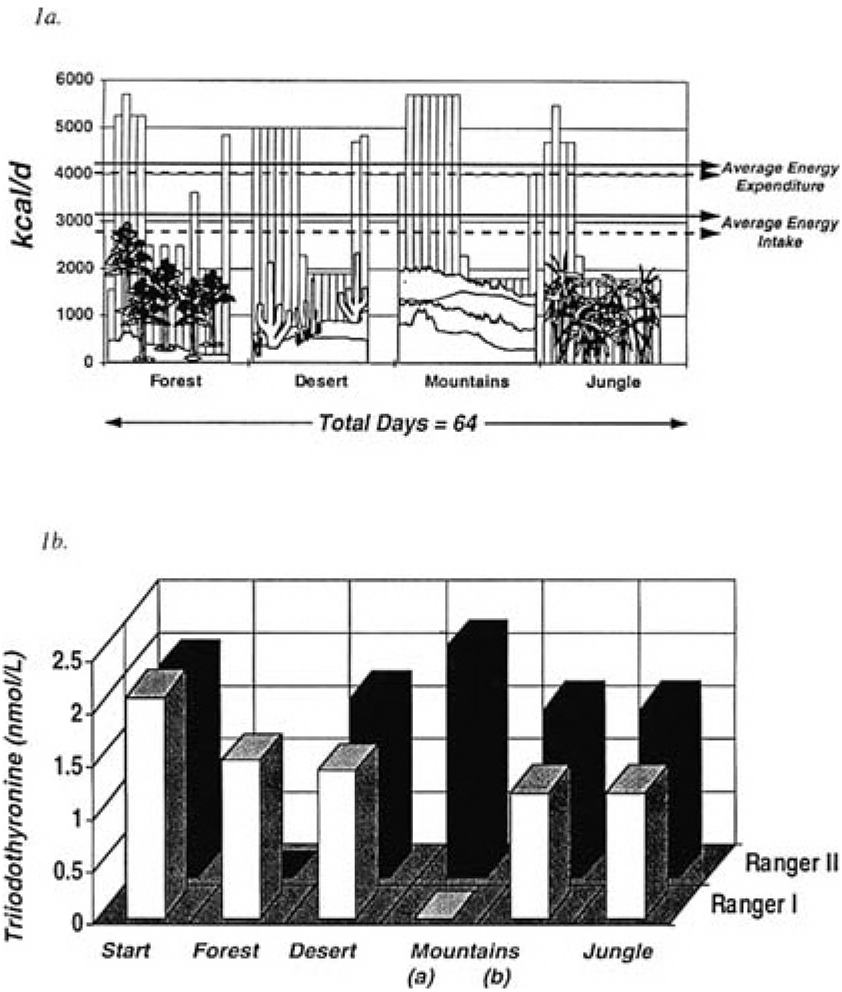


**FIGURE 14-1**

Daily intakes (A) are represented for soldiers through the four phases of training in the Ranger-II study. Dashed horizontal lines indicate the average daily energy intake and expenditure of the Ranger-I study, with a deficit of 1,200 kcal/d; solid lines indicate the effect of +400 kcal/d intake in Ranger-II, with a reduction in the deficit (to 1,000 kcal/d) and an increase in the total daily energy expenditure.

This increased intake in Ranger-II was adequate to maintain normal circulating levels of triiodothyronine (B), which suggests a more normal metabolic rate, but not necessarily a change in soldier work capacity or productivity.

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without necessarily decreasing productive work. However, the early responses to restricted energy intake in a normal subject do not include a change in resting metabolic rate; instead there is an increased utilization of body fat, reflected in weight loss and a change in the respiratory quotient.

Note that in all of these more extreme examples, including wartime coal miners, undernourished Columbian children, Army Ranger students, and volunteers in the Minnesota Starvation Study, all would have willingly consumed more calories, if they were offered. In normal circumstances, it is assumed that appetite would increase energy intakes following voluntary underconsumption before energy expenditure is noticeably affected. At least at the extreme level of deprivation of Ranger students, there was a strong hunger drive even in the face of multiple stressors.

## Specific Tests of Performance

The measurement of physical performance end points is not a trivial task in the context of military field studies. Unlike the picking of tea leaves or cutting of sugarcane, most military work does not readily lend itself to quantification through measurement of a single end product that signifies productivity. A few studies have successfully tested work productivity, such as a recent examination of the metabolic costs of a sustained-operations howitzer firing simulation, where the number of rounds loaded and fired could be assessed over discrete periods of time (Sharp and Vogel, 1992). However, as it is difficult to measure work productivity in military field settings, operational rations have been typically assessed for their effects on specific work capabilities.

The specific types of physical performance expected of soldiers in different specialties have been previously characterized. A 1980 review of the specific fitness requirements of each Military Occupational Specialty (MOS) categorized all MOSs into one of five combinations of strength and aerobic demands (Vogel et al., 1980). Strength was a key aspect of many MOSs, but high aerobic demand (> 11.25 kcal/min) only occurred in association with high strength demands (> 40 kg lifted to waist height). There was no job specialty where the performance typical of a trained distance runner would be favored; thus, an appropriate evaluation of militarily relevant physical performance must involve more than aerobic fitness and, most importantly, should include strength assessments.

Tasks that represent realistic job requirements in these different categories have been constructed but are generally too complicated and difficult to control for the assessment of adequacy of rations. A representative task for the most demanding cluster of MOSs (e.g., infantryman) was "carry a 45-kg bag for 1

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km in 20 minutes"; a less-demanding MOS task (e.g., supply clerk) would require a soldier to "lift and carry 27 kg for 15 m, 40 times per hour." As a test becomes more complex, individual skill and motivation increasingly confuse interpretation of the tests, and test conditions may be more difficult to duplicate between sessions. The significant disadvantage of using these tasks as the end point measurement in a field study is that nothing is learned about the mechanism of the performance decline. Well-validated tests that assess different types of performance (with dependence on different energy sources) such as strength, muscular endurance, and aerobic capacity can better address nutrition questions and pinpoint the nature of the deficit.

Many studies have used expedient tests such as handgrip strength or scores on the Army Physical Fitness Test (APFT); unfortunately, these are not the tests of choice for a nutrition study. Maximal handgrip is used as an indicator of strength, but it lacks the desirable sensitivity to changes in nutritional status, as will be further discussed. Push-ups and sit-ups from the APFT reveal something about muscular endurance but are also somewhat dependent on strength, and they do not optimally isolate muscle groups of interest. The third test of the APFT, the 2-mi run, is a good surrogate measure of aerobic capacity (Daniels et al., 1984; Mello et al., 1988). The correlation between 2-mi run time and maximal oxygen uptake can be as high as $r = 0.9$, with a narrow standard error of ~ 3 ml/kg/min (Mello et al., 1988). This measure is the most useful of the "expedient" tests, if a good effort can be obtained from volunteers in the test. Purer tests of physical capacity, which at least differentiate muscle energy sources, such as a dynamic lift test for strength, the Wingate test (30 seconds of maximal cycling exercise against a relative resistance) for anaerobic power, and a treadmill test to exhaustion for maximal aerobic capacity, can be carefully monitored and reproduced in a standardized way (see Vogel, 1994).

A variety of factors must be considered in choosing the most appropriate physical performance tests for military field studies:

- Relevance to military task performance should be established.
- Type of performance must rely on energy sources of interest.
- High skill component may reduce the validity of repeated testing.
- One must be able to monitor the effort of individual subjects.
- Expedience of the test determines how many subjects can be tested.
- Safety of the test is critical to avoid injury and so that subjects can confidently give a best effort.

An important aspect of physical test selection is to use expedient tests that are reasonably reproducible and that soldiers may be willing to perform in a consistent manner. Tests with a large learning curve are generally unsuitable,

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particularly if no control group is available. For example, in the 44-d Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE), where soldiers remained in energy balance, a marked learning curve was apparent for the 38-cm pull (Figure 14-2). The maximal lift test and grip strength demonstrated better stability (Teves et al., 1986).

Testing strength with an isokinetic dynamometer can be very useful because specific muscle groups can be targeted, for example, representing upper body, lower body, and trunk muscle strength. However, this type of testing also tends to exhibit a learning curve (e.g., Patton et al., 1989), and it can be difficult to conduct in a field training environment, particularly with time constraints. It also produces a type of muscular contraction (constant velocity) that does not occur during normal muscular activity.

Performance in any of these tests is highly dependent on psychological factors, and they must always be considered in test interpretation. For example, a 5 percent decrement in maximal aerobic capacity may be statistically significant in a controlled laboratory study but has little meaning in a field exercise when other factors such as motivation, fatigue, and blistered feet are superimposed. The road march involves both strength and aerobic components (e.g., 12 miles with a 35-lb [15.9-kg] rucksack) and has high military relevance; however, it has usually been used in studies of large units where it

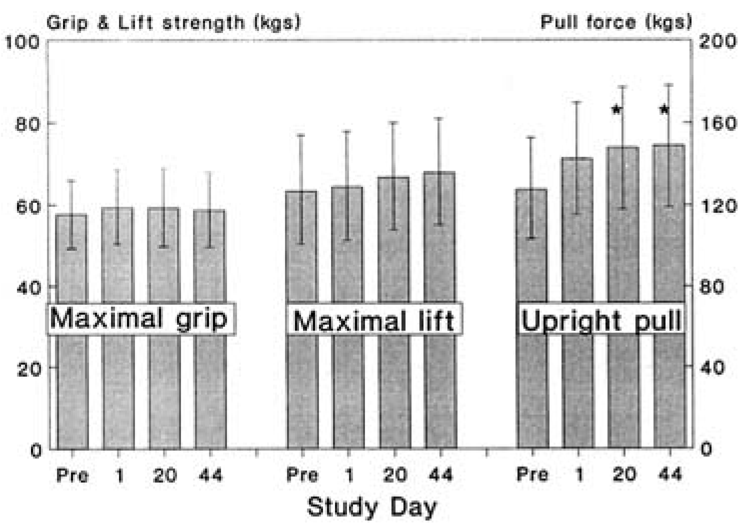


**FIGURE 14-2**

Three tests performed during the Combined Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) before the start (Pre), and at days 1, 20, and 44. The upright pull test revealed a significant technique effect, with significant improvements in the test at day 20 and 44 as soldiers improved the skill with repeated testing. The other two tests were more resistant to this effect. SOURCE: Teves et al., 1986.

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is even more difficult to interpret because individual soldier motivation cannot be closely monitored and best performances may not be elicited. At the end of a long field exercise, it is likely that most soldiers would rather be somewhere else doing something besides a performance test for an experiment. However, some soldiers will view the tests as a challenge and will try to improve on their previous performance or try to exceed the performance of their peers. Clearly, testing design, including such factors as the setting and rewards, are an important consideration.

## EFFECTS OF ENERGY DEFICIT ON STRENGTH

The consequences of energy deficiencies on muscular strength have been studied in a variety of military settings, but the results are highly dependent on the tests used. The desirable test is one that measures dynamic strength involving major muscle groups and represents typical Army lifting and carrying tasks (Harman et al., 1991). However, one of the most convenient strength measurements is the handgrip. This test may not be the most suitable predictor of militarily relevant strength capacity, and conclusions of the many studies that have used this test should be cautiously interpreted. Other tests such as the isokinetic testing of isolated muscle groups are mechanistically interesting but, as previously discussed, difficult to administer to a large sample and more prone to a learning effect that can confound pre- and posttest comparisons. The maximal lift test developed for strength screening of recruits who enter military specialties with high strength requirements may be a suitable test for performance nutrition studies, but this test also has a skill component that can confound results if not carefully administered. Although this maximal lift test has been used in only a limited number of nutrition studies, these results and those of a correlated jump test suggest levels of chronic undernutrition that may result in decrements in military performance (Frykman et al., 1993; Johnson et al., 1994).

Grip strength is exceptionally convenient, but compared to other tests, it is insensitive to large changes in nutritional status. Grip strength may be a useful prognostic end point for postsurgical survival of severely catabolic patients in hospital; however, in the hospital setting the deficit may be so extreme that the test is whether or not the patient can squeeze the doctor's hand. Applied to healthy soldiers, grip strength is unlikely to demonstrate any relationship to nutritional deficit. In the Ranger-I study with 16 percent decline in weight, there was no loss of grip strength or grip strength endurance (Johnson et al., 1994). Even the soldier with the most extreme weight loss of 23 percent of body weight in 8 weeks demonstrated no decline in grip strength performance. Other studies examining large weight losses and grip strength in

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soldiers have demonstrated no decrement (Taylor et al., 1957). Only the Minnesota Starvation Study charted reductions in grip strength, with a linear decline over 24 weeks with greater than 25 percent reduction in grip strength when subjects had achieved a 25 percent loss of initial body weight (Taylor et al., 1957). At this point, the men had lost greater than 15 percent of fat-free mass compared to less than 7 percent in the studies involving soldiers (Johnson et al., 1994; Taylor et al., 1957). Thus, grip strength appears to be well preserved until nutritional status is severely compromised.

The maximal lift test has been used in several nutrition studies, and a large Army data base exists from the testing performed by Marilyn Sharp and others (Sharp and Vogel, 1992). This test had the highest correlation with field performance ratings of light infantry soldiers (the correlation was further enhanced against a combined ranking of maximal lift and maximal oxygen uptake [$\dot{V}_{o2}$ max]) (Daniels et al., 1984). This test is also well correlated with other tests of muscular strength. Recently, Frykman et al. (1993) examined the relationship between power calculated from a maximal jump and the maximal lift test. In the Ranger-II study the two measures were correlated ($n$ = 50; $r$ = 0.7), and both the predicted power and the maximal lift declined by 20 percent of initial over 8 weeks of dietary restriction (Shippee et al., 1994). In the Fort Jackson study of female basic trainees, the measures were also correlated ($n$ = 168; $r$ = 0.7), suggesting that these two tests reflect similar aspects of muscular strength (Sharp et al., 1994).

Using the limited data available for these types of physical performance and weight loss in healthy individuals, the point of diminished performance can be interpolated (Table 14-1). Fogelholm et al. (1993) measured jump performance in a group of young male athletes and found no decline over a 3-wk period with a 5 percent weight loss. In fact, there was a slight increase in jump performance in another jump test, when weight was added to make up for the body weight lost. (There were also no changes observed in two tests of anaerobic power.) Soldiers consuming the Ration, Lightweight 30-day (RLW-30) for 30 days lost 5 percent of their body weight and demonstrated a significant 8 percent decline in one of the isokinetic leg extension strength tests (Askew et al., 1987). Strength performance was sustained in the comparison group of men who ate the MRE and lost only 1.6 percent of body weight. (Neither group demonstrated any change in grip strength.) In a study comparing the Ration, Cold Weather (RCW) to the MRE in a 10-d cold-weather scenario, soldiers lost 3 and 4 percent of body weight, respectively, but demonstrated no pre- to postchanges in the same isokinetic leg strength tests used in the RLW-30 test (Roberts et al., 1987). Very high urine specific gravities in this study suggest that a disproportionate amount of the 3 to 4 percent weight loss may have been due to dehydration.

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TABLE 14-1 Reductions in Body Weight Compared to Changes in Strength Performance Measured by a Maximal Lift Test, by a Related Jump Test, or by Isokinetic Testing of Isolated Muscle Groups (Other than Grip Strength)

| Study | Relative Change in Body Weight | Test Result |
|---|---|---|
| Teves et al., 1986 | No change | No change in lift. |
| Askew et al., 1987 (MRE*) | -1.6% | No decline in ILE.† |
| Roberts et al., 1987 | -3 to -4% in 10 days | No decline in ILE. |
| Fogelholm et al., 1993 | -5% in 3 weeks | No decline in jump. |
| Askew et al., 1987 | -5% in 4 weeks | No decline in strength except in ILE. |
| | ------------------------------------------------------ | |
| Frykman et al., 1993 | -13% in 8 weeks | -21% in lift; -21% jump power |
| Johnson et al., 1994 | -16% in 8 weeks | -24% in lift |

NOTE: ---, change to demonstrate performance decrement
* Meal, Ready-to-Eat ration.
† ILE, isokinetic leg extension.

In the Ranger-II study, a 13 percent decline in body weight over 8 weeks was associated with a 21 percent decline in both jump power and maximal lift; a significant decline in absolute jump height, even with the work advantage of this decrease in body weight, was also noted (Frykman et al., 1993). In Ranger-I (where grip strength demonstrated no decrease), maximal lift declined by 24 percent (the jump test was not performed), and body weight declined by 16 percent (Johnson et al., 1994). From these results, it can be concluded that strength performance is adversely affected sooner than handgrip data would suggest (> 16 percent weight loss) but not at weight losses of less than 5 percent, and possibly only at weight losses exceeding 10 percent (Table 14-1).

These conclusions are limited because they are based exclusively on data derived from physically trained men, often with larger-than-average muscle mass. Although a larger muscle mass increases metabolic requirements, physiological adaptation to training would conceivably delay the decline in muscular strength during an energy deficit. In any case, physically elite soldiers will retain a proportionately larger functional strength. For example, in the Ranger studies, soldiers lost 20 percent of their maximal lift strength, but this severe decline in strength only reduced them to the average strength of normally nourished soldiers (Johnson et al., 1994).

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It cannot be determined from the available data if strength declines are gradual with progressive weight loss or if they are associated with a sudden decline at some threshold level of energy restriction. A gradual decline in strength would be expected if the primary factor is simply muscle mass, while a threshold pattern would fit a metabolic limitation (e.g., muscle enzyme or substrate deficiency) imposed by some critical level of deficit.

Perhaps the decline in strength represents a combination of these two possibilities; loss of muscle mass during energy deficiency involves specific reductions in the fast twitch fibers, with better preservation of slow twitch fibers (Henriksson, 1990). A study of Swedish men on ski patrol (1,500 km/50 d with 25-kg backpacks) demonstrated the effects of energy deficit combined with prolonged low intensity (45 percent of $\dot{V}_{o2}$ max) training. For 2 weeks of this study, the men subsisted on Swedish army rations (4,000 kcal/d) but expended an estimated 5,000 kcal/d (measured by heart rate and calibrated to individual bicycle exercise tests). At the end of this period of energy deficit, muscle biopsies from the triceps and the vastus lateralis indicated a decrease in muscle fiber size for Type IIa ("fast twitch") but not for Type I ("slow twitch"). Following an additional 5 weeks of training without energy deficit (food provided ad libitum) the fast twitch fibers returned to baseline size (Schantz et al., 1983). Similar findings of decreased fast-to-slow fiber ratios with energy deficit have been reported from animal studies (Goldspink and Ward, 1979) and severely overweight subjects (Russell et al., 1984). This effect may be mediated through nutritional influences on thyroid hormones, where reduced circulating thyroid hormones produced by energy deficit as observed in the Ranger studies produce a reduction in Type IIa fiber size (Caizzo et al., 1992; Henriksson, 1990).

## EFFECTS OF ENERGY DEFICIT ON AEROBIC CAPACITY

Aerobic capacity has been examined (by treadmill testing) for soldiers in several nutrition studies involving energy deficits (Table 14-2). Compared to the results of the Minnesota Starvation Study, the changes observed in these studies seem almost trivial. A 25 percent loss of body weight was associated with a decline in maximal oxygen consumption ($\dot{V}_{o2}$ max) of more than 40 percent. In contrast, body weight losses of around 10 percent produced 10–15 percent declines in $\dot{V}_{o2}$ max in a 24-d lab study with restricted rations (Taylor et al., 1957) and in a 60-d field study of Ranger students (Johnson et al., 1976). Even smaller weight losses have been associated with declines in excess of 10 percent of $\dot{V}_{o2}$ max. The most energy-restricted group in the

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TABLE 14-2 Reductions in Body Weight Compared to Changes in Treadmill Maximal Oxygen Intakes of Physically Active Soldiers Participating in Various Nutrition Studies

| | Sample Size | Intakes | Duration | Body Weight (kg) | | $\dot{V}_{o2}$ max (liter/min) | |
|---|---|---|---|---|---|---|---|
| Study/Subgroup | (no. of soldiers) | (kcal/d) | (d) | Pre (±SD) | Δ (%) | Pre (±SD) | Δ (%) |
| Askew et al., 1986 | 15 | 2,200 | 12 | 71 ±2.9 | **-2.8** | 3.9 ±0.56 | **-5.7** |
| Askew et al., 1987 (MRE)* | 17 | 2,780 | 30 | 75 ±2.1 | **-1.6** | 4.2 ±0.45 | **-10.2** |
| Askew et al., 1987 (RLW-30)† | 16 | 1,950 | 30 | 79 ±1.8 | **-5.0** | 4.3 ±0.33 | **-14.8** |
| Consolazio et al., 1979 | 10 | 3,500 | 10 | 71 ±8.8 | 0 | 3.0 ±0.22 | **-2.0** |
| Consolazio et al., 1979 | 7 | 1,500 | 10 | 79 ±4.0 | **-3.7** | 3.4 ±0.39 | **-7.4** |
| Consolazio et al., 1979 | 11 | 1,000 | 10 | 74 ±8.3 | **-5.0** | 3.1 ±0.36 | **+5.0** |
| Consolazio et al., 1979 | 10 | 600 | 10 | 71 ±18.5 | **-3.6** | 3.1 ±0.68 | **-11.0** |
| Johnson et al., 1976 | 14 | 1,200–3,700 | 60 | 72 ±9.2 | **-9.4** | 3.5 ±0.44 | **-14.1** |
| Taylor et al., 1957 ("53")‡ | 6 | 580 | 12 | 75 ±10.7 | **-7.4** | 3.5 ±0.38 | **-4.0** |
| Taylor et al., 1957 ("54")§ | 13 | 1,010 | 24 | 69 ±11.3 | **-10.2** | 3.6 ±0.62 | **-10.1** |

* Meal, Ready-to-Eat control group in the Ration, Lightweight 30-day study.
† Ration, Lightweight 30-day experimental group.
‡ Experiment "53" (1953) at the University of Minnesota, using soldier subjects.
§ Experiment "54" (1954) at the University of Minnesota, using soldier subjects.

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jungle ration study of Consolazio et al. (1979) demonstrated a large decline in $\dot{V}_{o2}$ max after 10 days even though they lost only 3.5 percent of body weight. The MRE control group of a 30-d field ration test lost only 1.6 percent of body weight, yet demonstrated a 10 percent reduction in $\dot{V}_{o2}$ max (Askew et al., 1987). Even allowing a generous 5 percent variation in the reproducibility of a $\dot{V}_{o2}$ max, these various studies demonstrate decrements outside of this window and implicate factors other than the cumulative energy deficit.

Detraining[3] is almost certainly one of those factors. Aerobic capacity declines in the most highly trained men in most military training scenarios because their training levels are not maintained. For example, in basic training for the Danish army, men scoring the highest aerobic capacities at the start of training demonstrated significant declines 3 months later, while the men starting in poorer condition improved significantly (Hartling, 1975). Thus, standard military training usually does not meet the more specialized training requirements to maintain physical performance levels in the best-trained soldiers. This is a likely explanation for the large decline from initially high values for $\dot{V}_{o2}$ max in the Special Forces' soldiers who participated in the RLW-30 study. This decline cannot be readily attributed to nutritional influences because the nutritionally adequate MRE group demonstrated declines in aerobic capacity comparable to the RLW-30 group, which lost 5 percent of initial body weight (Askew et al., 1987). This reduction is also not explained by reductions in fat-free mass, the best correlate of aerobic capacity in undernourished populations (Spurr, 1986), because there was no significant change in fat-free mass in the MRE group and only a 2 percent reduction in the RLW-30 test group.

In a 1973 study of Ranger students, Herman Johnson and colleagues concluded that some of the 14 percent decline in aerobic capacity might be attributable to "fatigue-induced lack of motivation to continue" (Johnson et al., 1976, p. 13) on the treadmill at the end of the course. Fatigue has also been found to hamper postcourse testing in the more recent Ranger studies, and one might speculate how different some results would be after even 24 hours of refeeding and sleep. Johnson et al. (1976) answered this question with respect to aerobic capacity. Three days after the end of Ranger training, following sleep and ad-libitum refeeding, the soldiers had recovered from nearly 10 percent to within 2 percent of their original body weight but still demonstrated a significant decrement in aerobic capacity (-6 and -9.4 percent of initial $\dot{V}_{o2}$ max for two groups tested). Thus, the reduced $\dot{V}_{o2}$ max was not simply due to an acute muscle glycogen depletion, although this is a contributor (Jacobs et al., 1983), nor was it due to a poorer performance by sleep-deprived

[3] Detraining is the reduction in fitness that occurs with a change to an environment with a reduced training stimulus.

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Rangers, although a decrease in efficiency has been measured (both resting and submaximal exercise oxygen consumption increased) after 5 days of sleep deprivation and severe energy deprivation in Norwegian rangers (Bahr et al., 1991). It was also not evident that the changes were produced by any deficiencies in cardiac function, at least as might be manifested in electrocardiogram abnormalities (Johnson et al., 1976).

The pattern that emerges from all of these studies suggests that energy deficits resulting in 10 percent weight loss produce decrements in $\dot{V}_{o2}$ max; there is some question about changes attributable to lower levels of weight loss (Figure 14-3).

Reductions in aerobic capacity could be important because physical work capacity is largely determined by maximal aerobic capacity (Spurr, 1986). Physical tasks in the Army may involve short bursts of high-intensity work but more typically involve work at less than 40 percent of maximal aerobic capacity (Table 14-3). Thus, Ira Jacobs and colleagues (1989) have demonstrated that short-term activities such as running an assault course can approach maximal effort, but foot marches and other longer duration activities invariably result in self-pacing to ~35 percent of maximal aerobic capacity. This is a typical upper limit for sustainable work rates in other physically demanding

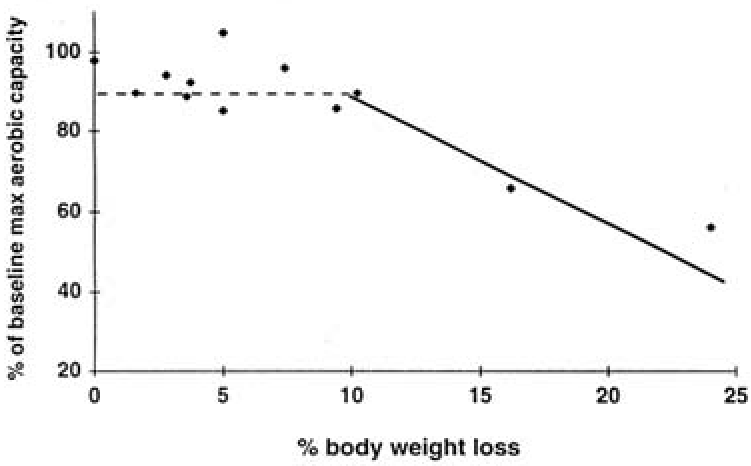


**FIGURE 14-3**
Changes in maximal oxygen uptakes (relative changes in absolute uptake, not corrected for body weight changes) compared against reductions in body weight in various studies detailed in Table 14-2.
If the two groups tested in the Ration, Lightweight 30-day study are discounted on the basis of their initially high aerobic fitness and greater susceptibility to detraining, a threshold at approximately 10 percent weight loss can be projected from the results of Johnson et al. (1976), Taylor et al. (1957), and the extreme results of Keys et al. (1950). Below this level of weight loss, measured changes fall within an 8 to 10 percent range of test reproducibility.

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professions for a normal 8-h workday (Spurr, 1986). Moderate reductions (e.g., 15 percent) in aerobic capacity from chronic undernutrition are not likely to have much impact on low-to-moderate levels of work (e.g., 35 percent of maximum); thus, a soldier normally working at 35 percent of maximal aerobic capacity would be performing at only a slightly higher relative work level (41 percent of maximum) (Spurr, 1986).

TABLE 14-3 Metabolic Demands of Various Military Tasks Performed by Elite Male Soldiers During a Canadian Field Exercise

| Activity | Oxygen Uptake (ml/kg/min) | Peak $\dot{V}O_2$(%) |
|---|---|---|
| Grenade assault course | 49* | 90 |
| Bayonet assault course | 48* | 89 |
| Unload vehicle | 36* | 67 |
| 10-km march with pack | 16 | 31 |
| Trench dig | 15 | 29 |
| Cross-country march | 18 | 35 |

* Predicted from heart rate; other measurements of oxygen uptake were made directly.
SOURCE: Jacobs et al. (1989).

Behavioral efficiencies can easily buffer this difference. For example, an accommodation effect has been demonstrated where soldiers, adequately fed, became more efficient and reduced energy requirements in a realistically demanding combat scenario (Sharp and Vogel, 1992). Soldiers performed a howitzer loading task, firing 640 rounds/d continuously for 45 hours. In the first half-hour cycle, crew members worked at nearly 50 percent of their peak aerobic capacity, but by their last cycle of loading, firing missions were completed in a shorter period of time, and work was achieved at less than 40 percent of peak aerobic capacity. This result suggests that to have a significant impact on this performance, maximal oxygen uptake must be markedly reduced, to a magnitude greater than that observed in any of the voluntary consumption studies (i.e., > 20 percent reduction).

The inconsistent relationship between maximal and submaximal tests supports the concept that motivation can overcome a modest physiological handicap (i.e., reduced $\dot{V}_{o2}$ max) during submaximal work. For example, a 10-km loaded foot march was performed at the start and end of the RLW-30 study and yielded conclusions different from the test of maximal aerobic power. The RLW-30 group that had suffered a 15 percent decrease in $\dot{V}_{o2}$ max demonstrated a significant improvement in road march time, with an average 5-min decrease in time to completion. In contrast, the non-deprived MRE test

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group participants apparently did not rise to the end-of-study challenge and demonstrated an average 10-min increase in time to completion (+13 percent over baseline time) (Askew et al., 1987). Similarly, in the 1-wk altitude MRE feeding study there was a significant decline in $\dot{V}_{o2}$ max (— 6 percent), but there was no change in the daily 2-h run performance; soldiers successfully completed 10.3 miles on the first day and 10.9 miles on the seventh day (Askew et al., 1986). These results lead to the inescapable conclusion that the changes in $\dot{V}_{o2}$ max that have been measured in various nutrition studies are of little consequence to soldier physical performance.

## SHORT-TERM STUDIES WITH HIGH-ENERGY EXPENDITURES

A different problem of underconsumption occurs in short-term (less than 1 week) missions when soldiers choose to forgo their rations because of weight limitations. An example of this is a special operations direct-action scenario where rations have a lower priority than ammunition and mission-essential equipment. Such high-intensity but short actions with limited food intake are training models for elite forces in many countries including Norway (Opstad and Aakvaag, 1981), Japan (Kosano et al., 1986), and Canada (Jacobs et al., 1989). This problem was also the focus of a concerted research effort by Consolazio and his colleagues (1979). Their concept was to determine the minimum requirements that would best sustain the performance of soldiers in such operations instead of assuming that soldiers would individually select the nutritionally optimal components from their ration packs.

Very high-intensity efforts can be maintained by elite soldiers over relatively short periods, as indicated by measured energy expenditures. The MRDA for energy for male and female soldiers is 3,200 kcal/d (2,800 to 3,600) and 2,400 kcal/d (2,000 to 2,800), respectively (AR 40-25, 1985), although there are special circumstances where actual energy requirements may be higher, such as the average 4,000 kcal/d measured in the 2-mi long Ranger course (Hoyt et al., 1993; Moore et al., 1992) and in British infantrymen on simulated jungle patrols (Haisman, 1970).

In the Ranger course, a deliberate energy deficit is imposed as a stress challenge to the students. However, energy balance is possible at this work intensity as demonstrated by a study of Gurkhas[4] eating an early version of group rations. In a 21-d exercise in the foothills of the Himalayas, these Nepalese tribal soldiers consumed 4,000 kcal/d, maintaining weight and reportedly improving biochemical and fitness status (Kark et al., 1945). Even

[4] Gurkhas are Nepalese men recruited to serve in elite infantry units in the British Army, known for their tenacity and courage.

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higher requirements for several-day periods may occur, such as 6,000 kcal/d during 1 week of mountain training in the Ranger course (Moore et al., 1993), at least 5,500 kcal/d for the 5-d U.S. Navy Sea, Air, and Land (SEAL) trainee "hell week" (Smoak et al., 1988), 5,300 kcal/d in Zimbabwean recruits during dry hot-weather operations (MJR Kaka Mudambo, Zimbabwe Defense Forces, unpublished results using doubly labeled water, 1994), and greater than 8,000 kcal/d in the 5-d Norwegian ranger course involving little or no sleep (Opstad and Aakvaag, 1981). It is questionable whether calorie intakes that are better matched to energy expenditure have any demonstrable benefit in these highest energy expenditure scenarios.

Compared to longer-term undernutrition, this direct-action scenario presents a different set of physiological limiters to physical performance. It is unlikely that even lean men will exhaust available fat energy stores in this period of time (a soldier with 10 percent body fat working at an exceptionally high 10,000 kcal/24 h for 5 days would not exhaust body energy stores). Instead of a gradual loss of lean mass to feed a chronic energy deficit, the problem is one of maintaining muscle function during high-intensity work without pausing for an appropriate rest phase ("overtraining"). For example, in Japanese rangers in a 93-h exercise (30- to 40-kg loads, 50-km travel in mountainous terrain, sleep < 3 h/d, consuming ~600 kcal/d), a marked increase in skeletal muscle enzymes indicates changes in muscle metabolism in response to the new level of strenuous work; however, there is only a small increase in myoglobin which suggests that this does not reflect actual muscle cell damage or catabolism (Kosano et al., 1986). Other examples of decrements in physical performance during continuous operations also suggest an overtraining phenomena related to higher-than-usual work loads. This effect has been observed in a study of 8-d continuous field artillery operations (Legg and Patton, 1987) and a 5-d scenario also involving upper body exertion such as load carriage (Murphy et al., 1984); in both cases, with minimal weight losses, upper body muscular strength and endurance significantly decreased. In another 8-d field artillery scenario with somewhat lower work levels, no decrements were observed (Patton et al., 1989).

Acute "overtraining" effects may also include depletion of energy sources, which may not be restored to initial levels simply by increasing carbohydrate consumption (Jacobs et al., 1983). Thus, this is a special subset of the underconsumption problem that does not appear to benefit from increasing consumption. In fact, whether or not soldiers deprive themselves of food for a 3- to 5-d direct-action mission probably has little effect on their short-term performance, as long as they ingest sufficient carbohydrate to prevent ketosis and obtain adequate mineral supplements to replenish losses (Krzywicki et al., 1979; Taylor et al., 1954).

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## Norwegian Ranger Training: Intensive Training with Large Energy Deficits

Male cadets from the Norwegian Military Academy participate in a 5-d ranger course as part of their training program. This course typically involves little or no sleep, and daily energy expenditure has been estimated to be greater than 10,000 kcal (Opstad and Aakvaag, 1981). When the cadets receive 1,500 kcal/d, they typically lose 4 to 5 percent of body weight and demonstrate a shift to an increased fat energy utilization during exercise (Bahr et al., 1991). Most of the weight loss is from fat, which has been further demonstrated by the triglyceride emptying of abdominal and gluteal adipocytes obtained both pre- and posttraining by biopsy (Rognum et al., 1982). The effects of increased energy intake were examined with the addition of 6,400 kcal/d over the 1,500 kcal/d normally given to cadets. The high-energy group still lost body weight (o.6 kg) but substantially less than the control group, which was fed 1,500 kcal/d (3.6 kg). There were no differences in performance between the two groups when compared for time on a 1-km assault course (days 2, 3, and 4), with 20 kg of combat equipment on a 350-m assault course requiring balance and agility (day 5), or on marksmanship scores (days 3 and 4) (Rognum et al., 1986). Although there were no differences in physical or mental performance attributable to energy intake, by the fourth day of this course, observer evaluations of all cadets rated them as totally ineffective soldiers (Rognum et al., 1986). This conclusion was attributed to the effects of sleep deprivation.

In other, more-controlled laboratory studies of short-term high-energy deficit, tests of power, such as the Wingate test, and tests of isometric strength, including grip strength, have usually not been affected (Consolazio et al., 1967; Henschel et al., 1954; Hickner et al., 1991). However, Henschel et al. (1954) noted a reduced capacity for anaerobic work during 4.5 days of starvation. This finding was based on a substantial increase in lactate levels following a 75-s anaerobic treadmill run and a decrease in calculated efficiency of ~8 percent (Henschel et al., 1954). These changes occurred without a decrement in maximal aerobic capacity. Bahr et al. (1991) have noted a 15 percent decrease in efficiency following the 5-d Norwegian ranger course, measured at a fixed work load involving 30 minutes of treadmill at 50 percent of maximal oxygen uptake. In both of these short-term starvation studies, the decreased efficiency has been related to the increase in fat utilization. In both cases, the absence of food also produced severe gastric distress, presenting other potential complications to assessment of work performance (Henschel et al., 1954; Oektedalen et al., 1983).

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## Canadian Forces Commandos Study: Intensive Training With Small Energy Deficits

Studies by Ira Jacobs involving Canadian Forces Commandos have examined the effects of supplemental carbohydrate feeding on physical performance and muscle glycogen levels during a 5-d high-intensity field training scenario (Jacobs et al., 1983, 1989). These studies include comparison between a group of soldiers receiving standard field rations (3,880 kcal/d offered; 3,350 kcal/d consumed) and a group receiving an additional energy supplement (5,420 kcal/d offered; 3,720 kcal/d consumed) to increase caloric intake above normal requirements to more closely match the requirements of this cold-weather exercise (5,500 to 6,500 kcal/d) (Jacobs et al., 1983). This situation reflects another form of "voluntary" underconsumption, where soldiers have difficulty ingesting enough energy to meet very high demands.

In this study, a variety of strength parameters decreased from baseline levels, on the order of 15 percent, and aerobic capacity declined by 6 percent. These results should be interpreted as part of the "overtraining" phenomenon and may also include fatigue and motivation components in the posttesting. There were no differences between the two groups in terms of performance decrements or in muscle glycogen concentrations (Jacobs et al., 1989).

Results of the study illustrate a problem for which a nutritional intervention has not yet been devised: the replenishment of muscle glycogen levels during a continuous effort without rest or with extraordinarily high daily energy expenditures (Costill et al., 1988). Endurance efforts such as the Tour de France may appear to be similar paradigms, but they differ because soldiers in these field exercises may not have rest periods greater than 2 hours at any given point, while cyclists usually have overnight rests.

## CONCLUSIONS

The conclusions of Taylor et al. (1957) still ring true:

> It seems reasonable to conclude that a loss of about 10 percent of the body weight is an acceptable compromise in a survival situation when the intake of calories and salt are adequate to prevent extracellular dehydration and significant hypoglycemia(p. 429).

They added that "it must be remembered that these results are limited to young men in good physical condition and that the rate of weight loss is important"(Taylor et al., 1957, p. 429). However, it appears that even a very high rate of weight loss for a short duration (< 1 week) probably has little effect on physical performance, as evidenced by the work of Consolazio, Johnson, and others. The primary concern during weight loss involves loss of muscle

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strength, but this loss requires a substantial loss of muscle mass, occurring with body weight losses at least in excess of 5 percent and possibly 10 percent of initial body weight. Even a 15 percent decline in aerobic capacity has relatively little effect on soldier performance when it involves work at normal sustainable levels. As in the example of the field artillery men who adjusted their relative work load through increased efficiency, soldiers could readily accommodate a change of this magnitude. In the case of overnourished soldiers, some weight loss is likely to be beneficial to health and performance.

Women have not been studied in the context of physical performance and weight loss in field conditions with operational rations. Such studies may provide a quite different relationship, since aerobic and upper body strength capacities are usually lower to begin with, and female soldiers are more prone to iron deficiency. However, female soldiers may perform better than men at low-intensity work during high-energy deficits because of their greater capacity for fat metabolism and larger fat stores.

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# 15

# Impact of Underconsumption on Cognitive Performance

*Mary Z. Mays*[1]

## BACKGROUND

Conditions on the modern battlefield require that all soldiers be able to perform at their peak. Moreover, higher than normal levels of physical or intellectual performance may be required for long periods of time. Subtle deficits in intellectual behavior can dramatically degrade combat effectiveness, which requires sustained vigilance, precise reasoning, and prompt decision making under duress. The outcome of military nutrition research must be rations that are readily consumed in quantities sufficient to fuel maximum intellectual and physical performance. Thus, the question of whether underconsumption is reliably associated with measurable degradation in intellectual behavior is of considerable concern to developers of military rations.

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Military nutrition researchers have not taken this responsibility lightly. The history of American, Canadian, and British research on military rations is easily traced from the World War II era to the present. Rations have been studied in temperate, hot, cold, and high-altitude conditions. Experiments as early as the 1950s (Korean War era) were conducted by interdisciplinary teams of researchers who measured the spectrum of biochemical, physical, psychological, and social parameters (Johnson and Sauberlich, 1982). These investigators went to great effort to use state-of-the-art technologies in harsh field settings, just as investigators do now. Investigators then and now found it was possible to do extensive testing in the field, but difficult to hold extraneous variables constant. However, the vast majority of the studies were not designed to study the relationship of underconsumption to cognitive performance, per se, or the ability of military rations to sustain cognitive performance under stress.

## Underconsumption

For the purposes of this review, *underconsumption* was operationally defined as a loss of gross body weight due to restrained eating, loss of appetite, or exertion. In all cases energy expenditure exceeded energy intake (underconsumption: kcal intake/kcal expended < 1.00). Failing to consume sufficient calories to maintain body weight (while in the presence of ample food) should be an anomaly, since under normal circumstances it is unlikely to have survival value. The circumstances under which it reliably occurs are riveting. Underconsumption should be particularly rare when the individual faces novel and strenuous work. For this reason, the soldier's underconsumption in field settings is especially intriguing. Although the camouflage-colored, armor-like packaging and shelf-stable, ready-to-eat engineering of military rations can easily explain a few days of underconsumption, they cannot explain the consistent finding that soldiers steadily lose weight when eating military rations for periods of 10 to 45 days (Askew et al., 1986, 1987; Carter et al., 1992; Hirsch et al., 1985; Johnson and Sauberlich, 1982; King et al., 1992; Popper et al., 1987; Roberts et al., 1987; Thomas et al., 1995; USACDEC/ USARIEM, 1986).

The boundary conditions of this phenomenon are as well established as its replicability. When soldiers were fed hot, cook-prepared, garrison-type meals in the field, they did not underconsume (Rose and Carlson, 1986), and when they were fed shelf-stable, ready-to-eat military field rations in a garrison-like environment, they did not underconsume (Hirsch and Kramer, 1993). Thus, the phenomenon of underconsumption is the result of an interaction between the field setting and the type of ration.

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Note that although underconsumption leads to weight loss, it does not necessarily lead to nutritional deficiency. The quality of food and the absolute amount of food consumed may meet physiological minimums, and thus prevent disease, but not prevent weight loss. Military rations are calorie dense and vitamin fortified to ensure that they will be nutritionally adequate even when consumed in small quantities (Askew et al., 1987; Johnson and Sauberlich, 1982; Lichton et al., 1988; Moore et al., 1992; Shippee et al., 1994; Thomas et al., 1995).

## Cognitive Performance

For the purposes of this review, *cognitive performance* was operationally defined as a score on a test of intellectual behavior (such as memory, reasoning, attention, vigilance, choice reaction time, arithmetic, or information coding). Cognitive performance is influenced by, and often confused with, psychomotor performance and mood. *Psychomotor performance* was operationally defined as a score on a test of skill or ability (such as sensation, perception, coordination, mobility, agility, reaction time, or pursuit tracking). Observations made by investigators or investigators' confederates about the cognitive or psychomotor performance of subjects were considered separately due to the subjective nature of such observations. *Mood* was operationally defined, in this review, as any self-report survey of cognitive performance, psychomotor performance, affective behavior, or nutrition-related symptoms. Interviews or standardized clinical tests of "personality," although designed to measure underlying traits, rather than transient states, were considered equivalent to self-report surveys of mood.

## Methodological Issues

This section provides a context for the extant data and suggests the kind of experiments that need to be done in the future. The majority of studies reviewed for this paper were designed to test the nutritional adequacy and acceptability of military rations or field-feeding systems. The relationship of underconsumption to cognitive performance was not the main focus of the studies. These studies were not concerned with the degree of stress imposed by the field setting and how that stress might affect eating behavior or cognitive performance. The design of the experiments and the analysis of the results did not provide the opportunity to determine the relative contributions of underconsumption, the field setting, and the interaction (of underconsumption and the field setting) to changes in cognitive performance. Consequently,

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these studies will not yield straightforward conclusions about cognitive performance. Despite this problem, they must be examined, because they constitute the only database on the effects of underconsumption on cognitive performance.

### Field Settings

A variety of contextual factors present in the field setting reduce eating and sustain a pattern of underconsumption even when it is not adaptive (Hirsch and Kramer, 1993; Meiselman and Kramer, 1994). The engineering of military field rations contributes to underconsumption, no doubt, but it is likely that eating cold rations, eating during short breaks, eating by yourself, performing demanding physical exercise, and performing challenging intellectual tasks contribute far more. These conditions of the social and physical environment influence cognitive performance as well.

Military field exercises (and combat deployments) dictate a dramatic change from daily routines. By necessity, they greatly restrict the activities of soldiers, limiting their ability to maintain a normal routine for relaxation, personal hygiene, and so on. Moreover, in any given field exercise, at least some of the following conditions are present: 24 h/d exposure to harsh climates, primitive latrines, minimal privacy (in mixed-gender and same-gender settings), separation from family, sleep loss, and danger. These conditions remove the normal discriminative cues that control a variety of behaviors and may increase free-floating anxiety. This kind of stress has been shown to disrupt cognitive performance (NRC, 1986) and to contribute to underconsumption (Hirsch and Kramer, 1993).

### Normative Data

In order to separate the impact of underconsumption, per se, from the impact of the field setting, the baseline of normal cognitive performance must be adequately defined. Units often spend weeks preparing for a field-training exercise. In the days immediately prior to departure, soldiers are typically too busy to eat and sleep regularly. In many cases they experience a growing anxiety as they anticipate performance evaluation, the rigors of field living, the potential danger of the operation/exercise, or separation from family. Unfortunately, baseline data on cognitive performance were typically taken immediately before departure to a field-training site. Furthermore, baseline measurements were typically the first experience the soldier had with the specific cognitive tests. Low estimates of baseline cognitive performance might

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have obscured the degree to which performance was actually degraded by underconsumption and the field setting.

## Control Group Data

A second issue that surfaces whenever a study involves comparison against a baseline is the issue of whether a "practice effect" enhanced or attenuated the treatment effect. One approach to eliminating a practice effect was to use cognitive tests that required such common skills that no practice was required; that is, a test on which (in the absence of any experimental manipulation) performance typically shows little change over repeated trials. Another approach was to engage subjects in a large number of practice trials to ensure that performance was asymptotic. Yet another approach was to refuse to give subjects feedback on their performance so that they were unable to derive successful strategies for improving. Each of these approaches runs the risk of making the test relatively insensitive. Studies did not typically include a control group, which would allow a practice effect to be quantified or to serve as a covariate in the analysis of treatment effects.

Furthermore, in order to separate the impact of underconsumption, per se, from the impact of the field setting, the field setting must be kept constant across a control group that does not underconsume and a treatment group that does. In many field-ration studies, the treatment group ate one field ration, while the control group ate another. They shared the same field setting, but both ate field rations, both underconsumed, and both lost weight. Thus, it was impossible to determine whether underconsumption, the field setting, or some interaction of the two influenced performance on cognitive tests.

## Cognitive Performance Tests

The difficulty of defining the relationship between underconsumption and cognitive performance is brought into perspective by considering the difference between measuring body weight and measuring cognitive performance. Body weight can be measured simply, accurately, and reliably using commonly accepted methods. Moreover, the standard error of measurement on any given weighing instrument can be easily established and is quite small (± 0.1 percent) relative to what is considered a meaningful change in body weight (± 2.0 percent). In contrast, error in measurement on a given cognitive test is often equal to a meaningful change in performance. Similarly, regardless of whether weight loss is due to loss of water, fat, or muscle (or some unique combination of the three), change in body weight accurately reflects the total

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loss. The total score on a battery of cognitive performance tests, however, may not accurately reflect the degree of change in one of the components comprising the battery. A long-standing and seemingly unresolvable controversy surrounds the search for an optimum set of tests of cognitive performance. The controversy has plagued numerous disciplines as disparate as intelligence testing (Scarr and Gallistel, 1993), military selection and classification (Butcher et al., 1990; Sperl et al., 1992), clinical neuropsychology (Kane, 1991; Matarazzo, 1992; Retzlaff et al., 1992), neurotoxicology and behavioral pharmacology (Iregen and Letz, 1992; Kane and Kay, 1992), as well as nutrition research (NRC, 1986). Over the last 50 years, military nutrition researchers have used individual tests, batteries of tests, obviously different tests, quite similar tests, the same tests in different media, and the same tests with different instruction sets.

### Environmental Conditions at Testing

Because field-ration studies are by their very nature repeated-measures studies and because they are necessarily conducted in the context of an operational scenario, one of the most difficult aspects of the study to control is the context of performance testing. Factors such as the illumination, ambient temperature, availability of chairs and desks, time of day, and so on, often were not within investigators' power to control and varied dramatically across the different testing sessions within an experiment. All of these factors have been shown to influence performance on cognitive tests (Kane and Kay, 1992; Kreuger and Babkoff, 1992; NRC, 1986). This background noise probably realistically mimics the conditions for which the rations are designed. When the purpose of a study is to determine whether cognitive performance is grossly degraded by extended subsistence on a specific ration, the variance in extraneous variables is largely irrelevant. However, when the purpose of the experiment is to determine the degree to which a specific level of consumption influences cognitive performance, this variance reduces the ability to characterize the effect precisely.

### Performance Motivation

Several field studies reviewed for this chapter described the remarkably high or low levels of motivation that soldiers brought to the experiment. In some cases, soldiers acted as though the experiment was a contest, with a winner to be declared at the end, and so performed well above normal limits. Conservely in other cases, soldiers expressed frustration with what appeared

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to them to be pointless laboratory tests and so were unwilling to exert themselves.

This problem is exacerbated by the fact that intact groups are used for treatment and control groups in most field-ration studies. That is, a platoon or company that has worked together for many months and has one role in the exercise is compared to another with a somewhat similar role. Not only does this influence the type of statistic that should be used in analyzing data, but it increases the probability that there will be several alternative explanations for experimental results. Whatever differences the groups bring to the experiment may interact in subtle and unpredictable ways with the experimental treatment.

Furthermore, leaders have an unmistakable impact on soldier attitudes and performance during the experiment. Unless all unit leaders (1) understand and value the purpose of the experiment to the same degree, (2) articulate it equally well to their subordinates, and (3) place the same importance on compliance with the experimental protocol, the groups are likely to have very different levels of motivation. This is particularly true when there is no way to conceal from one group how it differs from another, as is the case when two very different rations are compared. One group may perform better than another or improve its performance over time due to a placebo or expectancy effect (Adair, 1973).

## Consideration of Individual Differences

The range of weight change was quite large in many of the studies where there was an average weight loss (Askew et al., 1987; Hirsch et al., 1985; King et al., 1992; Popper et al., 1987; Thomas et al., 1995). That is, there were soldiers who gained weight, while the majority of their peers lost weight. Similarly, the range of performance on cognitive tests was quite large in some instances (Askew et al., 1987; Hirsch et al., 1985; King et al., 1992; Popper et al., 1987; Thomas et al., 1995). Some attention was devoted to post hoc analysis of data after separating test groups into subgroups of those who lost weight, those who did not, and those who gained weight, but results were equivocal. No systematic attempt has been made to identify individual differences (in experience, workload, food preference, metabolism, personality, etc.) that could account for the willingness or ability to consume sufficient rations to maintain weight or that could influence cognitive performance in these settings.

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### Investigator Bias

Investigators have tended to underreport or denigrate changes in cognitive performance when their clinical judgment suggested that these changes were not purely cognitive or were likely to be reversed with simple refeeding. However, this begs the issue, since momentary inattentiveness or confusion can have fatal consequences in military field settings.

## Influence of Underconsumption on Cognitive Performance

The literature on simple underconsumption of military rations is astonishingly consistent. In the absence of substantial mental or physical stress, weight losses of 6 percent or less over periods of 10 to 45 days produce no meaningful degradation in cognitive performance (Askew et al., 1986, 1987; Hirsch and Kramer, 1993; Hirsch et al., 1985; Johnson and Sauberlich, 1982; Lichton et al., 1988; Popper et al., 1987; Roberts et al., 1987; USACDEC/ USARIEM, 1986). Moreover, moderate levels of underconsumption enhance cognitive performance for 3 to 15 days. This should not be surprising given that food deprivation has been a routine component of animal learning experiments for the last 50 years. The controversy over the role of food deprivation in learning consumed researchers for many years (Spence, 1956; Spence and Spence, 1967), but deprivation's ability to stimulate purposeful action is well-established and has obvious adaptive significance. Clearly, when consumption remains above 50 percent of what is required, deficits in cognitive performance are minor even when underconsumption continues for weeks (Keys et al., 1950). Not so clear is what happens when consumption falls below 50 percent; apparently the rate of decline in cognitive performance is steady and significant (Shippee et al., 1994).

Food deprivation is a special case of underconsumption. Individuals may consume 100 percent of what is available, but because an inadequate amount of food is available, they suffer the same consequences as those who "voluntarily" underconsume. The classic study of food deprivation was conducted by Keys et al. (1950). It was designed to deliberately induce a slow but steady, and eventually severe, loss of weight. It serves as a benchmark against which to measure the consequences of severe underconsumption in the absence of other stressors. Their data show little indication of meaningful changes in the cognitive performance of the group, although subjects repeatedly reported memory lapses, inability to concentrate, obsessive behaviors, apathy, and lethargy. Case study accounts of participants in the Keys et al. study (Schiele and Brozek, 1948) verified psychiatric deterioration

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in 25 percent of the subjects. Post hoc analyses of accounts of behavior during famines (Graham, 1993; Keys et al., 1950; NRC, 1986), as well as popular accounts of men lost at sea and prisoners of war confirm that noncognitive behaviors of lethargy, helplessness, and hypochondria disrupt cognitive performance but do not prevent individuals from functioning in an intelligent and purposeful, even heroic, manner when the opportunity arises to procure food or escape the situation.

A series of studies conducted in the 1960s evaluated the combined effects of restricted intake and exercise (Consolazio et al., 1967, 1968; Johnson et al., 1971). Fasting for 10 days produced severe malaise, abnormal electroencephalograms, and lapses in memory and alertness. A diet of 420 kcal of carbohydrate per day for 10 days also produced abnormal electroencephalograms, while a diet of 500 kcal of carbohydrate and protein per day for 10 days did not. Johnson and Sauberlich (1982) reviewed a series of American, British, Canadian, and Australian studies of the minimum number of calories per day needed to sustain military performance while on 4- to 14-d patrols in temperate and extreme environments. These studies are a testimony to the resilience of cognitive and psychomotor behavior. For example, Crowdy et al. (1982) studied the impact of 12 days of underconsumption on soldiers during arduous training and testing in the Malaysian jungle. The control group's average energy intake (kcal) was 82 percent of their energy expenditure (kcal), and the food-deprived group's intake was 47 percent, creating rapid weight losses of 3 percent and 6 percent, respectively. Performance on marksmanship, vigilance, arithmetic, and coding tests did not significantly change from baseline across the 12 d of testing, nor did it differ significantly between the groups.

In contrast, studies of dieters and restrained eaters (Green et al., 1994; Rogers and Green, 1993; Rogers et al., 1992) and studies of individuals suffering from bulimia nervosa or anorexia nervosa (Jones et al., 1991; Laessle et al., 1990; Szmukler et al., 1992) suggest that underconsumption combined with other stressors significantly degrades cognitive performance. The training of special operations forces combines food deprivation with several stressors, including exercise, sleep deprivation, danger, and personal evaluation (Hudgens et al., 1992; Marriott, 1993; Moore et al., 1992; Opstad et al., 1978; Pleban et al., 1990; Tognum et al., 1986; Shippee et al., 1994). Under these circumstances cognitive performance degradation (from 5 percent to 35 percent below baseline) occur within a few days, although it is not clear what role underconsumption, by itself, plays in including these deficits.

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## PROPOSED RELATIONSHIP OF UNDERCONSUMPTION TO COGNITIVE PERFORMANCE

Based on their extensive review of the literature on starvation, Keys et al. (1950) estimated the rate of weight loss that could be expected over time as a function of underconsumption. Their estimates have been confirmed over the years in a variety of settings, including military field settings. Figure 15-1 illustrates their predictions concerning weight loss over a 60-d period.

The simplest hypothesis for the relationship of underconsumption to cognitive performance would be to suggest that it corresponds to the relationship of underconsumption to weight loss. That is, for each *X* percent drop in consumption, there would be a predictable *Y* percent degradation in cognitive performance. However, data from two thorough studies of underconsumption (Keys et al., 1950; Shippee et al., 1994) suggest that the relationship is not so simple. Figure 15-2 summarizes the change reported over time in cognitive performance and body weight in these two studies (both dependent measures are expressed as a percent of baseline to facilitate direct comparison).

Subjects in the Keys et al. (1950) study did not show meaningful decrements in cognitive performance, even when weight loss was substantial. Soldiers in Ranger training experienced significant changes on similar measures of cognitive performance with a similar degree of weight loss (Shippee et al., 1994). These differences could be interpreted as evidence that the high degree of physical and mental stress inherent in Ranger training degrades cognitive performance, but food deprivation does not. However, consideration of all the extant data suggests that the expected value lies somewhere in between semistarvation data gathered in the Keys et al. study and the Ranger data. That is, even though a precise comparison of results across the studies reviewed for this paper was not possible, a general pattern of results did emerge. This pattern is illustrated in Figure 15-3.

Underconsumption, in contrast to undernutrition, leads to energy deficiency rather than disease. Thus, mild to moderate underconsumption of nutritionally-fortified military field rations should lead to transient inattentiveness, indifference, and confusion rather than severe lapses in reasoning, comprehension, or memory. Substantial deficits in cognitive performance could occur, however, if other factors in the field setting interact with underconsumption (Askew et al., 1987; Colloway, 1982; Cohen et al., 1982; Gorsky and Calloway, 1983; Keys et al., 1950; Krueger and Bobkoff, 1992; NRC, 1986; Shippee et al., 1994; Webb, 1982).

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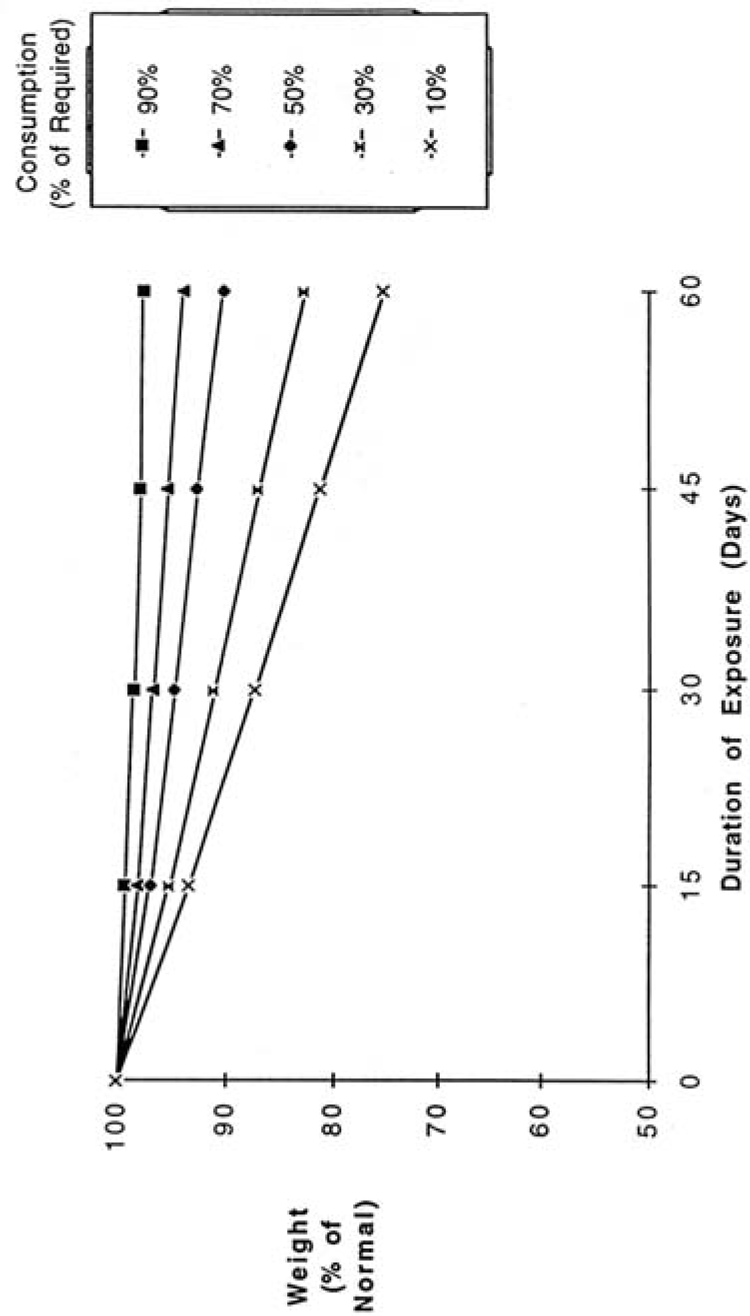


**FIGURE 15-1**
Weight loss as a function of consumption over days. SOURCE: Developed from data published in Keys et al. (1950).

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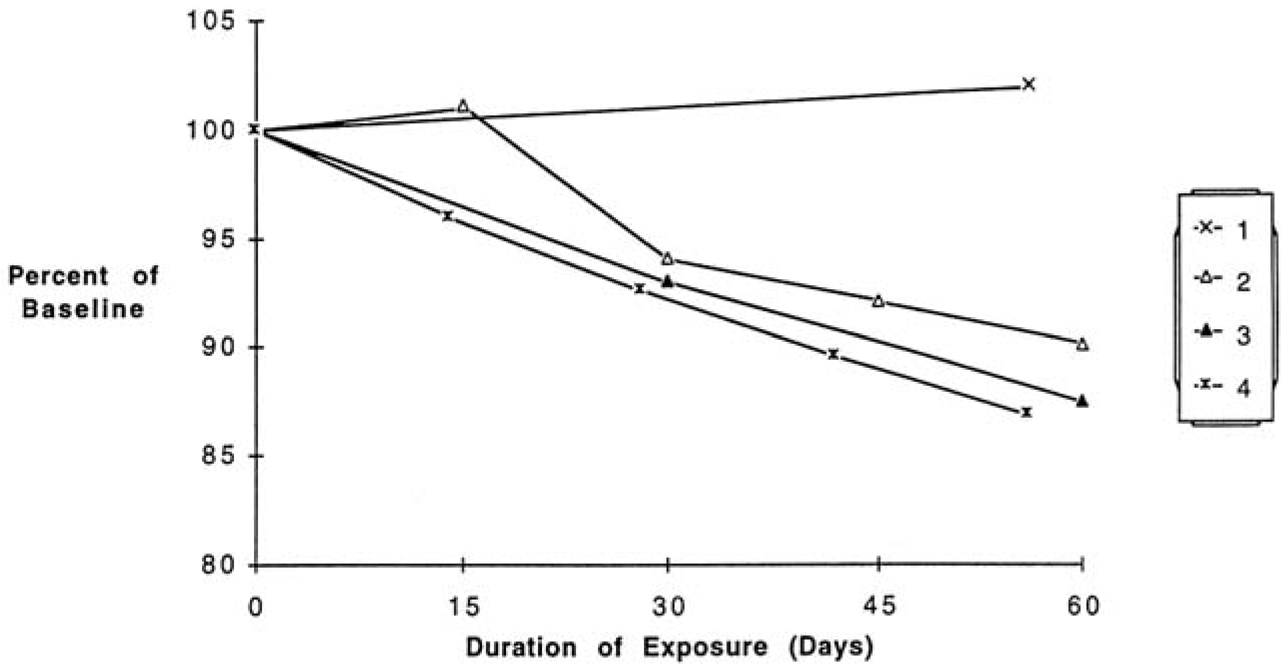


**FIGURE 15-2**
Relationship of cognitive performance to weight loss over days in two experiments. 1 = mean performance on tests of memory, reasoning, and spatial perception for subjects in a semistarvation study (adapted from data published in Keys et al., 1950); 2 = mean performance on tests of memory, reasoning, and spatial perception for soldiers in Ranger training (adapted from Shippee et al., 1994); 3 = mean body weight for soldiers in Ranger training (adapted from Shippee et al., 1994); 4 = mean body weight for subjects in a semistarvation study (adapted from Keys et al., 1950).

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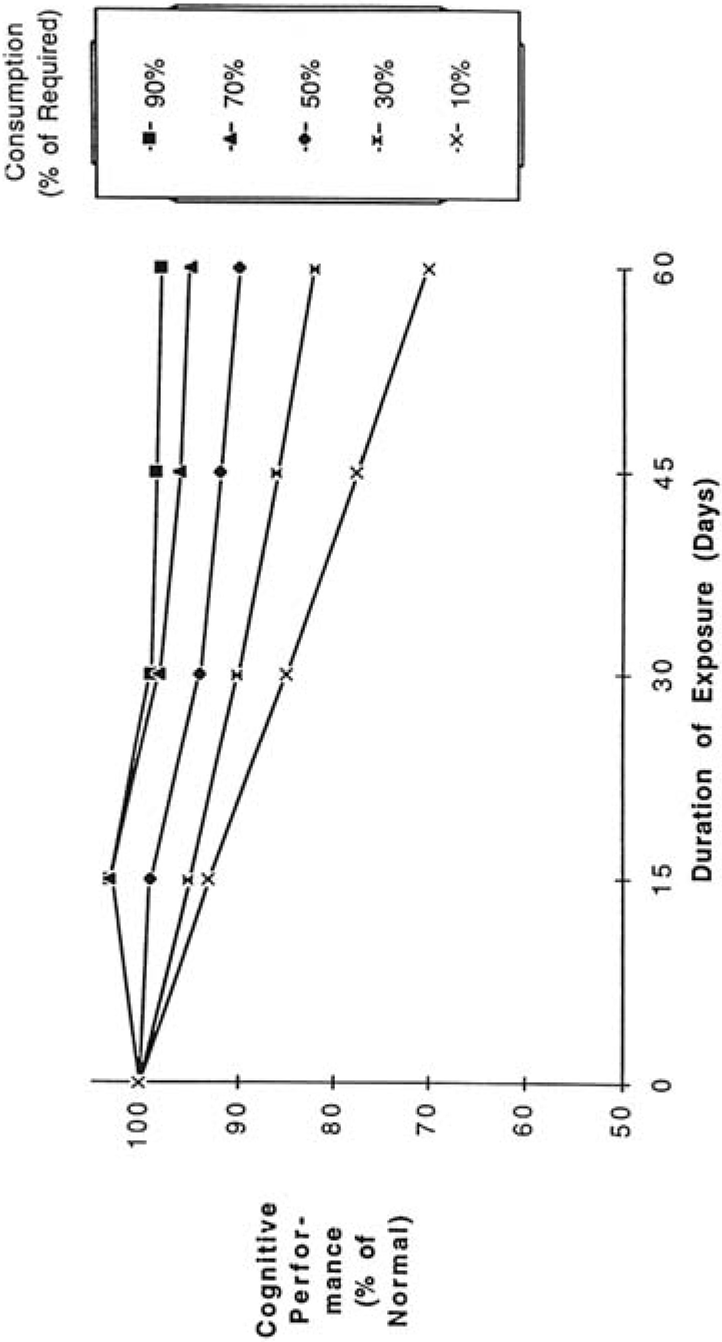


**FIGURE 15-3** Proposed relationship of cognitive performance to consumption over days.

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## CONCLUSIONS AND RECOMMENDATIONS

Given the methodological issues discussed, the value of Figure 15-3 lies primarily in its ability to generate discussion, rather than its accuracy as a summary of extant data. The apparent robustness of cognitive performance in the face of 5 to 10 percent losses in body weight over the course of 10 to 45 days may be genuine or may be attributable to experimental designs which failed to (1) account for the contextual cues present in field settings, (2) accurately define baseline performance, (3) provide an appropriate control group, (4) hold testing conditions constant, (5) assess motivation levels, and (6) analyze individual differences. If this robustness is genuine, it would appear that there is no practical significance to the underconsumption typically seen among soldiers subsisting entirely on military rations. However, the problem in *accepting* mild to moderate underconsumption lies in the fact that combat is fraught with emotional, mental, and physical stressors. Field studies that mimic these circumstances suggest that underconsumption exacerbates deficits in cognitive performance created by the situation. In that case, methods to reduce underconsumption could sustain and enhance combat effectiveness.

The available data do not unequivocally answer the question of whether underconsumption seriously degrades cognitive performance. More importantly, they do not provide the military leader with sufficient information to weigh the cost of measures designed to increase consumption (taking time for regularly scheduled meals, heating food, eating in social groups, etc.) against the potential benefit (enhanced combat effectiveness). Just as the Army has doctrine about water discipline and work-rest cycles, which are couched in terms of the number of casualties they can prevent, the Army needs doctrine delineating the benefits of food discipline. A series of carefully designed dose-response field studies need to be conducted for the sole purpose of defining the increase in cognitive performance that can be derived from a specific level of consumption.

In summary, the following conclusions can be drawn from military nutrition field studies:

- Weight losses of 6 percent or less over a period of 10 to 45 days produce no meaningful degradation in cognitive performance.
- Consumption levels of 75 percent to 90 percent of requirements may enhance cognitive performance in the first 3 to 15 days.
- Consumption of 50 percent or less of requirements will significantly degrade cognitive performance, especially when combined with forced exercise and sleep deprivation.

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- The available data do not provide sufficient information to develop a food-discipline doctrine that could be used to sustain cognitive performance under stress.
- A field study designed specifically to assess the relationship between specific levels of consumption and cognitive performance could form the basis for an effective food discipline doctrine.

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## DISCUSSION

EILEEN G. THOMPSON: Is it your sense that the cognitive tests that are represented here include really fairly complicated kinds of tasks?

MARY Z. MAYS: Yes. In some cases they were very complicated and in some cases they were very realistic and relevant to military performance.

The cognitive tests used in these studies ran the gamut from batteries composed of simple tests like those commonly found on clinical neuropsychological tests to performance tests which lasted for hours and involved complicated decision-making tasks. In every case, they failed to show any effects of underconsumption when body weight losses were less than 6 percent.

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# 16

# The Functional Effects of Carbohydrate and Energy Underconsumption

*Stephen Phinney*[1]

## INTRODUCTION

The physiological effects of energy restriction are wide ranging, and they also depend in part on the mechanism through which the energy deficit is induced. This chapter focuses on the functional effects of caloric and/or carbohydrate restriction in the short and long term and also addresses their potential clinical implications.

## CARBOHYDRATE RESTRICTION

In the first half of this century, vigorous debate was waged between nutritionists advocating a high-carbohydrate, low-fat diet for optimum physical

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performance and explorers who promoted a high-fat diet as the most compact and practical form of nutrition under adverse conditions. This debate was fueled on the one hand by the experience of trappers, fur traders, and explorers who lived among the native peoples of the North Plains and Pacific Northwest in the United States and throughout Canada. A typical voyageur working for the Canadian Northwest Company was given a daily ration of 1.25 lb (0.6 kg) of pemmican[2] as his sole ration. Nourished by this food, these men would paddle and portage loaded canoes across great distances via the lakes and rivers of Canada. The other side of the debate was fueled by the cultural experience of the English, whose empire depended upon a navy fed by salted meat and dried ship biscuits.

Additional information for this debate was derived from the experiences of polar explorers in the latter half of the nineteenth century. Following the disaster of the Royal Navy's Franklin Expedition, debate raged around the issue of food spoilage as a causative factor, while the issue of scurvy was not addressed (Feeney, 1989). This denial of the problem of scurvy probably contributed to the demise of the Scott South Pole Expedition half a century later. In the center of this debate, on the side of high-fat rations, was a unique individual named Vilhjalmur Stefansson, who followed 15 years of living among the Inuit peoples of the far north with 40 years of living among a (not so) different culture at Dartmouth College. In order to salvage his veracity from the attack of more conservative nutritionists, this university professor consented to live under continuous observation for 1 year in the Russel-Sage Research Unit at Bellvue Hospital in New York in 1928. During the year, he ate only meat, fat, internal organs, and bone marrow, without benefit of fruits, vegetables, complex carbohydrates, or supplemental vitamins or minerals. The results of this unique experiment (McClellan and Dubois, 1930) document his continued state of excellent health without any signs of scorbutic symptoms. He had no obvious limitations of physical capability and maintained the ability to vigorously jog around Central Park at a speed that taxed his attendants (McClellan and Dubois, 1930).

As a result of this debate, considerable scientific evidence was assembled on the side of a high-carbohydrate diet. Marsh and Murlin (1928) published data showing improved high-intensity cycling performance on a high-carbohydrate as opposed to high-fat diet. Similar findings were reflected in the famous studies of Christensen and Hanson (1939).

During the Second World War, the issue was again raised as to the potential use of pemmican as a weight-efficient ration for troops under adverse conditions. To test this question, a study was conducted among Canadian troops who were performing winter maneuvers. Soldiers were switched

[2] Pemmican was a Native American preparation of dried meat mixed with hot animal fat in roughly equal proportion. When cooled, the solid product was compact and stable for months.

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abruptly from their standard rations to 1.25 lb (0.6 kg) of a dried meat and fat preparation per day as their sole source of calories. In addition to this food ration, soldiers were given tea, matches, and cigarettes. No time was allowed for the troops to adapt to this diet, as they were asked to continue their arctic maneuvers, pulling all of their gear long distances on sleds. By the third day of the experiment, it was determined that the troops were debilitated, and the experiment was halted (Kark et al., 1946).

During the 1960s, elegant work by Bergstrom and Hultman (1972) clearly defined muscle glycogen as the limiting factor in high-intensity physical performances. This work formed the basis for the current dogma that carbohydrate is an obligate nutrient to support both high-intensity aerobic as well as resistance work.

In the mid-1970s, the work of Blackburn, Bistrian, and Flatt in developing very-low-calorie diets for major weight loss brought renewed interest in ketogenic diets back into the scientific literature (Bistrian et al., 1975a; Blackburn et al., 1973). Because exercise is recognized to be an important component of weight loss and weight maintenance regimens, there were valid concerns that ketogenic diets devoid of carbohydrate would cripple this vital component of multidisciplinary treatment regimens. Empiric observations based upon self-reported physical activity, however, indicated that obese humans on very-low-calorie diets recovered endurance physical performance after a few weeks, and were then able to extend themselves beyond normal daily activities into more purposeful athletic pursuits during the severe calorie-and carbohydrate-restricted phase of such diets. This observation was documented in a number of controlled studies (Phinney et al., 1980, 1988), although the work of Bogardus et al. (1981) suggested that very-high-intensity intermittent activity was still limited by carbohydrate restriction. The other uncontrolled variable in these studies was the contribution of reduced adiposity to changes in cardiopulmonary and muscle dynamics.

To address the question of exercise capacity during ketosis, this laboratory undertook a study of lean, healthy males who were given a diet patterned after the reported food intake of the Inuit people (McClellan and DuBois, 1930). The eucaloric ketogenic diet (EKD) consisted of 15 percent protein and 85 percent calories as fat and provided 1.75 g of protein per kg reference body weight daily. The diet was supplemented with calcium, magnesium, potassium, sodium, trace minerals, and vitamins. Five of the research subjects were highly trained cyclists who were studied both at rest and with exercise (Phinney et al., 1983). Empirically, the cyclists found the first week of the carbohydrate-free diet to be especially difficult, but they still kept up their training schedule of approximately 100 mi/wk (161 km/wk). By the third week of the EKD, their self-reported endurance capability had returned to normal (i.e., two or three of

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them could hold a pace line[3] at 23 mi/h (37 km/h) for longer than was comfortable for the carbohydrate-fed investigator). In the fourth week of the study, all five subjects underwent repeat testing for peak aerobic power and endurance time to exhaustion. Although the substrate for muscle performance was dramatically shifted away from carbohydrate toward fat (mean exercise respiratory quotient [RQ] declined from 0.83 to 0.72), neither endurance time to exhaustion nor peak aerobic power (5.0 1/min of oxygen consumption) was altered over the baseline values. These observations confirm the prior report by U.S. Army Lieutenant Frederick Schwatka (Stackpole, 1965) that prolonged endurance effort was clearly feasible given 2 to 3 weeks of adaptation to a high-fat diet.

These observations underscore the fact that three critical factors must be met for ketogenic diets to be safe and to allow endurance physical performance: adequate salt, adequate major and trace minerals, and adequate time for adaptation. The study by Kark et al. (1946) ignored all three, achieved the obvious result, but got the wrong answer. A minimum of 3 g of sodium per day is necessary to maintain a euvolemic state in the face of the natriuresis of fasting (or more accurately, the natriuresis of ketosis). The inclusion of salt in the dried meat product or the provision of bouillon as a purposeful supplement is thus necessary to meet sodium needs. With adequate sodium to maintain euvolemia, and increase in aldosterone is avoided, making renal potassium conservation more effective. Nonetheless, the minimum potassium needs of the EKD remain undefined, and potassium intake is best supplemented. In addition, a straight meat and fat diet does not provide adequate calcium or magnesium, and these must also be purposely supplemented to avoid muscle cramps and cardiac dysrhythmias. Importantly, the Recommended Dietary Allowances (NRC, 1989) have not been validated as the appropriate standards for this type of diet. And finally, adaptation to the EKD involves a time lag of 2 to 3 weeks to allow for induction of hepatic ketone production, followed by the suppression of skeletal muscle ketone oxidation to allow optimum ketone provision for central nervous system energy requirements.

An important unexplored issue is the optimum composition of the dietary fat that makes up 80 to 85 percent of the energy content of the EKD. It is not clear that all fatty acids are equally preferred by muscles and liver for fuel. Although a high omega-6 polyunsaturated fat intake may be optimum for cardiac health when fats are a minority of total calories, this is probably not true when fat makes up the vast majority of dietary caloric intake. As a first guess, then, one should look to the composition of human adipose tissue for guidance as to "the body's preferred mix of fats as fuel." Human adipose tissue is composed of monounsaturates as the primary class of fatty acids with

[3] A pace line is an aerodynamic formation of cyclists in which the lead position is changed at regular intervals.

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only moderate amounts of saturates and polyunsaturates. The Inuit diet, while high in marine lipids, still provided the bulk of calories as monounsaturated fatty acids, because the omega-3 fatty acids that naturally occur in marine sources represent only about 30 percent of total fat. All "native diets" of a ketogenic nature were inherently limited in omega-6 polyunsaturates. Thus any further work with this type of diet should focus on monounsaturates as a primary fuel source and avoid overfeeding either omega-6 or omega-3 polyunsaturates to avoid distorting membrane fatty acid composition and, with it, cellular function.

## ENERGY RESTRICTION

The majority of recent research involving caloric restriction has been the result of voluntary restriction to induce therapeutic weight loss. Depending on the weight of the individual and the desired degree of loss, reports of voluntary energy deficits have varied from a few hundred kilocalories to total starvation, with deficit durations lasting 6 months or longer (Keys et al., 1950; NIH Technology Assessment Conference, 1992).

Involuntary energy restriction is induced by unavailability of food or the lack of familiar or palatable foods. In addition, a caloric deficit will usually result if the composition of the diet is changed to reduce caloric density or absorbability.

Another method to induce a caloric deficit is to increase physical activity. This increase may not be immediately compensated for by increased food intake (Staten, 1991; Woo et al., 1982; Wood et al., 1988), although other reports indicate that appropriate compensation does occur (Woo and Pi-Sunyer, 1985). The mechanism through which the human system eventually perceives the deficit and compensates by increasing food intake remains poorly understood.

An additional mechanism that results in negative energy balance is the anorexia of illness or injury, with the energy deficit stemming both from reduced intake plus an increase in metabolic rate. This mechanism is probably mediated by tumor necrosis factor (previously called cachectin) and/or interleukin-1 (Moldawer and Lowry, 1988). Besides overt trauma or infection, increases in tumor necrosis factor and the resultant effects on systemic body function can result from muscle injury associated with excessive exercise for which one is not adequately trained. This cytokine response to unaccustomed amounts of exercise may be a factor mediating increased metabolic rate (and thus an energy deficit) following exercise (Phinney and Stern, 1993).

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## Early Effects of Caloric Deprivation

The early weight loss associated with caloric deprivation represents not just loss of adipose tissue but also loss of lean body mass. Even before this response, however, there is a net loss of body water associated both with glycogen depletion and also a net natriuresis if there is significant restriction of total calories and/or carbohydrate (Sigler, 1975). If the caloric restriction is quite marked (e.g., semistarvation or total starvation), the natriuresis becomes brisk within 2 to 5 days. To compensate, an increased sodium intake is required to maintain euvolemia. Impaired cardiovascular function and work performance result if this compensatory sodium intake is not maintained, because hypovolemia limits circulatory reserve and increased aldosterone leads to accelerated potassium wasting.

Another early effect of hypocaloric feeding is reduced metabolic rate. Depending on the degree of caloric restriction, resting energy expenditure can be reduced as much as 25 percent within the first 2 weeks of restriction (Taylor et al., 1957). Although this effect reduces the net energy deficit, the compensation is incomplete, and weight loss is unavoidable. This result has potential functional importance when severe energy restriction occurs in the context of low-temperature environments.

## Effects on Lean Body Mass and Function

Negative nitrogen balance is a common but not obligate early response to reduced food intake. With total starvation in an unstressed adult, lean body mass losses approach 0.5 kg/d, but with adaptation to nutritional ketosis, the daily rate of nitrogen loss is cut by a factor of 4 over 28 days (Cahill, 1970). With lesser degrees of caloric deficit, especially if some protein is provided, the degree of lean body mass wasting is attenuated, but the duration of time necessary for adaptation remains similar (Keys et al., 1950; Phinney et al., 1988).

In spite of the fact that the rate of nitrogen wasting is most pronounced early in a period of restriction, the physiologic effects are generally the result of cumulative losses over time rather than the absolute rate (Keys et al., 1950). Thus brief periods of even severe restriction have relatively little immediate effect on body structure and health, while the effects on physical performance are more likely due to depletion of muscle glycogen (resulting in impaired high-intensity activity) than due to effects on lean body mass (Davis and Phinney, 1990). With infection or trauma, however, the rate of nitrogen loss can reach such a magnitude that host defense against infection and wound healing are affected (Blackburn et al., 1973).

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### Energy Deficits Induced by Exercise

As noted above, an abrupt increase in exercise energy expenditure is frequently undercompensated by dietary intake. Although this increase results in weight loss, it is usually not accompanied by loss of lean body mass as long as protein intake remains adequate (greater than 1 g/kg reference body weight) (Wood et al., 1988). In this setting, early weight loss is attributable to loss of glycogen-associated water and body fat, but it appears to be well tolerated in even quite lean individuals (Taylor et al., 1957; Wood et al., 1988).

### Energy Deficits and Immune Function

Advanced protein calorie malnutrition is associated with impaired immune function (Bistrian et al., 1975b). This effect does not occur as a linear response with total body nitrogen loss, however, as even significant losses of lean tissue appear to be well tolerated without a reduction in the delayed hypersensitivity response as long as the rate of loss is modest (Keys et al., 1950). However, after significant lean tissue reserves are lost (e.g., lean body mass is reduced to 80 percent of normal), it takes less injury or stress to induce host compromise (Blackburn and Thorton, 1979). Thus, both resistance to infection and recovery from injury may be impaired if nitrogen losses are allowed to accumulate.

An additional effect of dietary restriction on immune function can result if intakes of vitamins and minerals (such as vitamin A and zinc) are reduced. Starting with a well-nourished adult, vitamin and mineral deficiencies take months to develop, but if they are allowed to occur, they contribute to impaired host defense independent of protein depletion.

## SUMMARY AND RECOMMENDATIONS

Calorie underconsumption generally has negative effects on lean body mass, physical performance, and host defense against infection. These effects can be forestalled by attention to protein, mineral, and vitamin intakes. Severe calorie or carbohydrate restriction can result in natriuresis, requiring sodium supplementation. Eucaloric ketogenic diets have some potential as a weight-efficient ration for humans. They can support prolonged endurance performance once subjects become adapted to them; however, intense anaerobic work is necessarily very limited on this type of regimen. Due to lack of experience with such diets, further research is needed to determine the proper fatty acid composition and the mineral and vitamin intakes that should accompany such a regimen.

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## DISCUSSION

RONALD SHIPPEE: Dr. Phinney, what do you think the protein is doing under conditions of severe water excretion? In other words, in providing an amount of protein, how much of it is being used as protein, and what would probably be used as amino acids, the main body musculature, and what percent of it simply is oxidized?

STEPHEN PHINNEY: To people who didn't hear the question in the back, the question was, how much of the extra protein that I count here, 1.5 is being used just for oxidation.

If someone is at 0 nitrogen balance, and they are eating 75 g of protein a day, then 75 g of protein were provided, then 75 g of protein, somewhere, depending on what they ate or what they had, is being oxidized.

If it takes 1.5 g of protein per kilo, it has to go to about twice that level to nitrogen balance. A severe flow of restrictions obviously has greater protein metabolism going on. And my guess is that at least part of that is used for gluconeogenesis to maintain brain function.

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Now, in the studies I showed you an adaptation of ketosis. There may be an uncomfortable thing. We might say, rather than giving that extra 75 g of protein, let's give 75 g of carbohydrate.

So, what you do in that is, you pull the rug out from under the ketoadaptive state. And you may not get the same ability to do that for prolonged exertion, but intermediate intensity of performance that I showed you we could do.

So, I am not sure that we are living on a perfect continuum there, in terms of having a wonderful substitution of carbohydrate and protein.

The way I am reading now is that when you get up to a level of 1.5 g of protein per kilo, some people begin to feel a little uncomfortable with that as being unnecessary. But it is well within the envelope of what the average adult American male typically eats.

ELDON W. ASKEW: In addition, in your weight-loss study, they maintained and actually increased performance capacity.

Did you have an activity monitoring during that? In other words, did they gradually become more active as they lost more weight and basically got more into shape, so to speak, and that had something to do with it?

STEPHEN PHINNEY: Again, the question is, in the weight-loss studies where we saw the improvement in endurance time, was there some improvement in activity? People lived within the metabolic research wards. They were allowed to leave the metabolic research ward on their own for employment or school.

We had people who agreed that they would not increase their exercise. We saw no increase in their peak aerobic power during the course of the studies. So, I don't think there was a training effect, but I can't absolutely rule that out.

WILLIAM BEISEL: A lot has been made well known that the advantage of intake is the declining protein efficiency goes down, but there are also a lot of studies out there that show that increased protein intake increased the efficiency of energy.

STEPHEN PHINNEY: It is always interesting to me, mostly I sit with Mary and Karl over a cup of coffee. I wish that they could stand up and show the data, but first of all, in the Ranger study, that we would ever be able to see a protein deficiency base.

But also, Mary and I have had a lot of discussions about this. Mary has the ability to sock it up, sock it up. So, when I look at her tests I have got a little problem. But you can't tell the immune systems to sock it up.

And Dr. Crane, who is an immunologist, in both studies, he had always had a problem, that we couldn't publish. If you look at human spots(?), they go down. So, they eat and it starts to come back up. Body weight is still going

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down. Body composition is still going down, and our measures are still going down. So, we look at this adaptive measure and that is looking a—looking at the slide with some increase, and now at your data in which there is some kind of flow—

KARL FRIEDL: Again, this is purely speculative, but back to one of my early slides, and that is, we have very little knowledge about the acute effects of changing exercise patterns.

We talk about sending people out there, and troops function in bursts. But again. I haven't seen it published, but Bill Evans told me a year ago that he has data showing that with the acute imbalance in exercise, during which people unaccustomed are resulting in muscle stiffness, they see an increase in circulating IL-1.

Bet we know that, among other things, that the effect of IL-1, and TNF is in part impacting the immune system.

So, acute injury effects, not gunshot wounds, not crush injuries, but maybe the rather subtle injury that comes from stiff muscles and sore muscles may be enough to down-regulate some of the things for our sensitive tests of immune function and therefore work.

And those might be the result of why you see some of those changes in immune function. But eventually, once you put them back in a garrison situation with adequate calories, these guys come back and respond.

The immune system sees the whole body all the time.

ELDON W. ASKEW: One thing that you made mention of, Dr. Phinney, about the secondary anorexia, due to cytokine production, we are beginning to think that there is a change in immune function, just like going to the field, because it is non-specific stress, perhaps, of going to the field.

And it occurs to me that if the anorexia that we see in soldiers who are going to the field might possibly be mediated or tied in to cytokine production and secondary effect on appetite and so forth. I don't know at this point in time.

STEPHEN PHINNEY: Since I have no knowledge, it is very easy for me to speculate that it could be very important and really deserves study.

JOËL GRINKER: There was an article in The *New England Journal of Medicine* that looked at the antibody side, and also showing it a couple of months later, by work done at the University of Michigan. So, there is a lot of the IL-1 and the others that these cytokines can cause the anorexia that is associated with disease and other situations where cytokines are related.

EILEEN THOMPSON: I was struck by comments that people made yesterday, that we are in a situation where people are going out into the field

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more often, and yet the studies that we have looked at so far seem to be sort of one-time semistarvation or some sort of—I know the same thing that yo-yo dieting issue, the fact that yo-yo dieting is shown to have a negative health effect in the Framingham study.

Is anybody doing anything to look at the impact of episodes like this on health issues? There are a lot of people doing it.

MARY MAYS: I mean, if you are asking if people are investigating that in an epidemiological compilation?

EILEEN THOMPSON: No, I meant in terms of these Army studies. You know, has anybody done a follow-up with the Rangers when they actually go out and do their thing?

MARY MAYS: I don't think there is a consensus that there is a real phenomenon.

STEPHEN PHINNEY: They supposedly do it only once. They pass the course, and they don't go through that again.

EILEEN THOMPSON: But then, if they are out there in Somalia or wherever, they are probably doing this underconsumption that you guys have been talking about.

So, in general, the sense is that this is probably only happening—this is not happening to these people on a regular basis and that it isn't a health issue.

MARY MAYS: I think I don't find that entirely valid because the types of folks that are going our on a repetitive and prolonged period field deployment, or are your support troops, they are not your combat troops—the Rangers and special forces—but it is the CSS community that is—it is a smaller trail.

I mean, the reconfiguration in the military over the last 15 and 20 years, the tail has shrunk. So, the support base for all these other folks is the same population.

So, when all these other lead elements go out, the same support element trails with them, although A, B, and C on the maneuver units, the Ranger units, if you will, those guys will rotate. But the guys who are supporting those people are the ones that are going out on very short-term functions and stuff. And we are seeing this particularly in the European community where these guys are going out to the major training centers, spending months upon months upon months, coming back for a 5 and 6 day break, bringing your laundry, balancing their checkbooks, and then going out again. And it is the same support troops, but not the same fighter population that is in training there.

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And these folks, these support folks, are not the focus of any of the major efforts in terms of reactions.

STEPHEN PHINNEY: Their food intake opportunities are different than what you would have in your line forces. I think they are very different. They usually have the vehicles, and they will pack them full of all kinds of stuff that they want.

KARL FRIEDL: At least they have the opportunity for doing a lot more. I think that we do need some more information on that.

MARY MAYS: The CSS community probably has more repetitive actions in terms of endurance type activities as opposed to short burst high peak activity. These are the guys doing the truck off-loads, the truck on-loads, the warehousing operation.

Yes, they perhaps—perhaps and not always—perhaps have more access to latrines and showers and so forth, those other things in terms of a stabilized group.

But I think there is too often a conclusion that there are performance requirements that are not as demanding. And I think that is a very untrue statement. I think in terms of total energy expending, I think that you are probably going to see this as the support troops are expending as much as the—

ELDON W. ASKEW: My comment was not to say that they are not working, that they have the opportunity, I think, for—I think that that is an area that needs to be looked at.

MARY MAYS: But those populations other than the Ranger group, because that is specialized training, has the inability to receive sufficient calories, because we are very good at delivering sufficient calories throughout the battlefield. It is the pattern that permeates the battlefield that we are talking about.

STEPHEN PHINNEY: To return to Eileen's original question, I do think that soldiers who go out in the field and come back, there is much yo-yo dieting going on. You know, they lose 5 pounds and 10 pounds. It is not the big yo-yo dieting. We don't know how that is happening.

(Brief recess.)

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# Part V

# Factors Underlying Food Intake and Underconsumption—The Eating Situation and Social Issues

IN PART V, THE PHYSICAL AND SOCIAL aspects of the eating situation are reviewed. As reported in Chapter 16, the physical situation of the field setting can adversely affect ration intake because of changes in meal timing, frequency, duration, regularity, and predictability. The author suggests improving the economics of the eating situation through beverage and ration supply during deployment; when and how long soldiers eat; ration type that maximizes sensory and hedonic appeal while minimizing preparation; and creating a more "meal"-like situation. An economic perspective is described as one way to integrate the development, testing, and use of military operational rations.

This is followed by an evaluation of food appropriateness to the eating situation in Chapter 18. Using consumer behavior and food cognitive-context research, the usefulness of appropriateness measures in ration development is highlighted. The person, food item, and eating situation interact with each other; therefore, it is important to consumption to match the ration to the environment for the soldier.

The discussion of chronobiology and biologic rhythms in Chapter 19 focuses on the influence that meal timing has on physiologic functions. For body weight maintenance, meals should be scheduled at the physiologically and logistically most useful times. A series of studies shows that meals scheduled at the conclusion of activity periods may enhance food intake.

In Chapter 20, research on the social facilitation of food intake suggests that food intake is increased by social setting. People eat more in the presence

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of others for a variety of reasons, with two of the most important being disinhibition and increased amount of time for the meal. Based on this research, group feeding and modeling are two social factors that can be employed to try to increase soldier intake. Clinical underconsumption (i.e., eating disorders such as anorexia nervosa, bulimia nervosa, and binge eating disorder) is the subject of Chapter 21. The familial, biological, behavioral, psychological, and cognitive aspects of eating disorders are presented for theoretical comparison with soldier underconsumption.

Finally, a proposal for increased ration consumption by the U.S. Army Natick Research, Development and Engineering Center (NRDEC) is outlined in Chapter 22. The author reviews strategies for improving consumption and acceptance of military operational rations and their effect using the relevant chapters in this volume. Long-term plans include designing new rations and increasing variety in current rations.

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# 17

# The Physical Eating Situation

*F. Matthew Kramer*[1]

## INTRODUCTION

Eating, like all human behavior, takes place within a physical context or environment. Recognizing that the environment has a significant role in food consumption, standard laboratory research is typically designed to allow conclusions to be made about one or more variables of interest while controlling for or eliminating the influence of other factors. The situation present during military field training would seem to be the antithesis of laboratory research in that researchers collecting data in this physical environment have minimal control over the factors that influence eating. Nonetheless, the disparate situations of lab and field can be brought together if one accepts Collier's (1989) assertion that eating behavior is determined by the economic context in which it occurs. This viewpoint acknowledges the role of specific factors but places less emphasis on any particular factor and more

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on the resulting overall context or environment in which the organism must operate.

The context is frequently labeled as economic because it is hypothesized that the organism—the soldier—chooses what, when, and how to eat in order to best balance the costs and benefits of the situation. For example, in a study conducted by Engell et al. (see Engell, Chapter 12 in this volume), subjects given a pitcher of water within reach during a laboratory lunch meal drank approximately twice as much water with their meal as did subjects who were required to walk across the room or a hallway to obtain water. Apparently the extra "cost" of obtaining water outweighed any motivation to drink water for physiological, sensory, or psychological reasons. It is reasonable to hypothesize that subjects in the higher cost conditions recognized that any fluid "deficit" could easily be met shortly after the meal and hence responded to the cost by decreasing fluid consumption while eating. If, however, subjects had reason to expect that they would be unable to drink for several hours after the meal, they might then have chosen to drink similar amounts of water in all conditions regardless of the differences in required effort. Likewise, for most people, ordering a meal in a restaurant is not purely a function of which meal would give the greatest hedonic pleasure, but a balance of pleasure with factors such as meal price, health concerns, occasion, hunger, time available for eating, and who else is present.

Collier's approach, thus, is not confined to the common research question of what organisms do when given the opportunity to eat. Rather it is an effort to capture the entire process of obtaining (or foraging for) food: locating, procuring, preparing, consuming, and metabolizing food in the broader context of the organism's overall existence. Admittedly, at times the situation is fairly simple. People pick one dessert over another for the simple reason that it tastes better, or they do not drink at dinner because they will soon be driving home. Still, the immediately simple, discrete decisions are obviously the product of a complex, ongoing process that takes a great many forces into account. Current models of optimization have yet to fully reflect what happens in actual situations, yet they do at the very least provide a sense of the importance of different viewpoints.

The impact of taking an economic viewpoint of the eating situation is that while any given factor may indeed have an influential role in human food consumption, that role will change with the specifics of the situation. The work of Collier (1989) and others (Hursh, 1984; Lea, 1978), for example, make apparent that the magnitude and type of consequences for specific factors will vary depending on the multiple inputs of the many variables relevant to the eating situation. Soldiers eating in a field scenario provide one instance of a complex physical environment in which accomplishing one's mission, obtaining sufficient nutrients, and meeting other needs or desires requires soldiers (and their commanders) to adopt strategies (preplanned or not) to achieve an acceptable outcome.

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Collier's work provides a schema for understanding a particular behavioral response (i.e., eating) within the overall context of the organism's existence, but it is less concerned with the specific physiological or psychological mechanisms mediating the behaviors that are seen. Woods (1991), in contrast, deals more with the internal milieux of the organism in describing how organisms learn about their environment and develop anticipatory responses to maintain physiological functioning at acceptable levels in the face of disruptive events such as a sudden influx of nutrients. This behavioral tolerance reflects both internal and external behaviors aimed at minimizing risk and maximizing safety. Woods' arguments fit well with those presented by Collier and others and could conceivably be seen as the microeconomic complement to the macroeconomic viewpoint described above or, perhaps, as the details of the interface of physiology and behavior. The importance of Woods' concepts in trying to understand underconsumption of operational rations lies in increasing one's awareness that not only must soldiers strive to follow the most useful strategies available in optimizing food intake, accomplishing their duties, and so forth, but they must attempt this in a physical environment where adaptive behaviors—especially anticipatory ones—learned previously may be relatively ineffective, inoperable, or even inappropriate.

This is not to say that particular proximate factors such as physiological variations, social conditions, or palatability are either unrelated or unimportant in determining food consumption. As a vast literature and the contributions to the present volume make abundantly clear, such proximate factors have a marked impact. However, in any environment, be it the real-life environment of the soldier in the field or a closely controlled meal situation in the laboratory, organisms do not typically respond to a given stimulus in a vacuum but rather achieve some sort of balance among all factors present. By controlling the eating situation, laboratory studies help to elucidate how a particular factor can influence behavior. Clearly, how this same factor influences eating in real life will vary depending on the other relevant forces present. The failures sometimes seen of generalization from the laboratory to the field (or the reverse) may be due more to researcher limitations in identifying and quantifying the forces governing food intake in real life, rather than to inherent flaws in the laboratory research itself.

The relevance of the viewpoints espoused by Collier (1989) and Woods (1991) to ration consumption is apparent in at least two lines of research. First, as noted previously, consumption (or lack thereof) of operational rations takes place within a complex environment in which a variety of forces impinge on the eating situation and soldiers' behavior. Prior investigations (c.f., Hirsch and Kramer, 1993) have repeatedly found that both simple and complex alterations of the situational aspects of eating have pronounced effects on ration consumption. Thus, understanding of ration consumption and development and implementation of methods to enhance ration intake (c.f., Hirsch, Chapter 9 in this volume) require investigation of both specific variables and the overall

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context. Second, as seen in Figure 17-1 and described by others in this volume (e.g., Baker-Fulco in Chapter 8 and Meiselman in Chapter 3), underconsumption of operational rations and consequent energy deficit is a consistent phenomenon in the field setting. This trend appears to be the case across a range of climate conditions, types of soldiers, and duration of the field training. Although other papers in this volume address specific risks of underconsumption and possible solutions, it is clear that soldiers generally do underconsume and that the low average consumption indicates that a significant number of soldiers are markedly below recommended energy intake.

This chapter will describe the overall feeding situation in which soldiers find themselves, focus on several especially pertinent areas in greater detail,

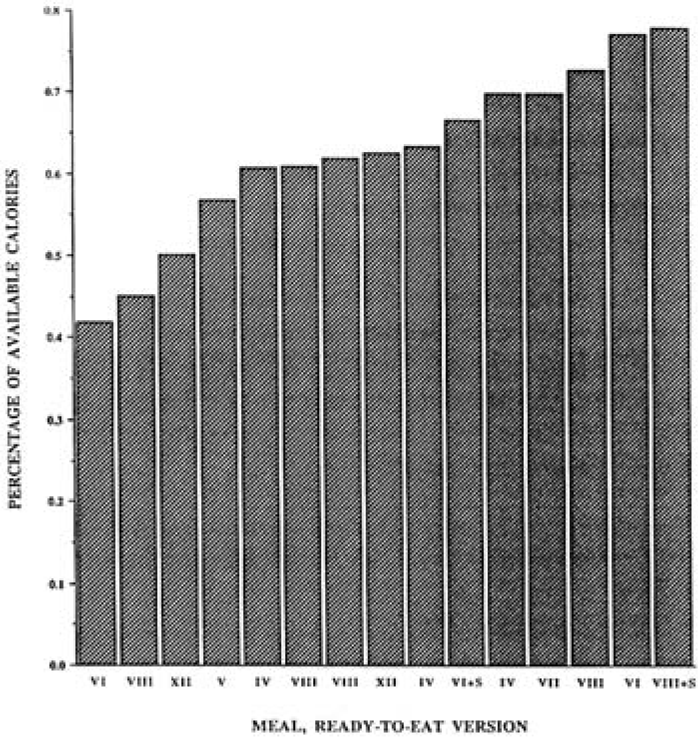


**FIGURE 17-1**
Mean daily caloric intake as a percentage of available calories for different versions of the Meal, Ready-to-Eat (MRE) operational ration.
Each bar represents the results from a specific study, with some studies having more than one condition. Some MRE versions are shown repeatedly due to multiple studies. SOURCE: Data adapted from Askew et al. (1986, 1987), Edwards et al. (1989), Engell et al. (1987), Hirsch et al. (1985, in press), Lester et al. (1993), Morgan et al. (1988), Popper et al. (1987), and C. Thomas (Personal communication, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., 1993).

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and attempt to show how each relates to an economic viewpoint of feeding behavior. The goal is to provoke thought, suggest ways to understand the outcomes seen, and offer alternatives for further research and practical recommendations to the military community.

## THE PHYSICAL SITUATION

No one description can capture the unique features of every field exercise. Nonetheless, a number of factors are typically present. Some of these factors will have a relatively direct impact on ration consumption, while other aspects, although not specifically linked to eating, can be expected to have gross effects on behavior.

### General Conditions

The goal of field exercises is to prepare soldiers and commanders for performing in real-life conflict situations. Thus, while varying from exercise to exercise, the field carries with it certain demands and costs. Soldiers, for example, are relatively exposed to the elements. If the weather is cold and wet, then it will be more difficult to prepare and eat a meal in comfortable conditions, as will also be the case for sleeping and other creature comforts. Being in the field generally increases the difficulty of obtaining food or other personal items or otherwise having the freedom of choice seen in day-to-day living. The physical demands of training, harsh weather conditions, and the evaluative nature of training exercises can also be significant stressors for the soldier.

The field situation also puts a high premium on activities that compete with eating. Given a choice between accomplishing a mission or eating a meal, soldiers and especially their commanders will generally forgo eating. Similarly, soldiers may be more apt to give up eating for other comforts such as dry clothing or sleep than might typically be the case when in garrison. This relative willingness not to eat even at times when food is available reflects what Lea (1978) would term *demand elasticity*.

#### Deployment to the Field

When troops are deployed to the field, the process can be lengthy and can involve significant food and water deprivation. For example, soldiers preparing to depart for Pohakuloa Training Area in Hawaii from Schoffield Barracks on Oahu might be awakened at 4 a.m. on the day of departure, actually leave several hours later, be transported from the airport to the training area, and

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then march to their designated location. During this time, soldiers might have little opportunity for eating or drinking and as a result might begin a training exercise in an already depleted state. The impact of soldiers' deployment or transportation to field training is apparent in Figure 17-2. Average hydration and weight changes during an approximately 24-h deployment were equivalent to approximately 50 percent of the total changes observed over an 11-d training exercise (Popper et al., 1987). Engell (see Chapter 12 in this volume) notes that lower water intake is associated with lower food intake, suggesting that soldiers who are dehydrated by deployment might consume less food as a strategy to maintain the ratio of food to water.

In addition to depriving soldiers of water or food, deployment may also effect ration consumption through disturbances of circadian rhythm. This effect will be particularly relevant for sudden and lengthy deployments such as those to Saudi Arabia and Somalia. Although the effects on food intake are not as apparent or well known as those for sleep or body temperature patterns, it seems likely that disruption of circadian rhythms or sleep loss would exacerbate the effects of irregular schedules on consumption described below.

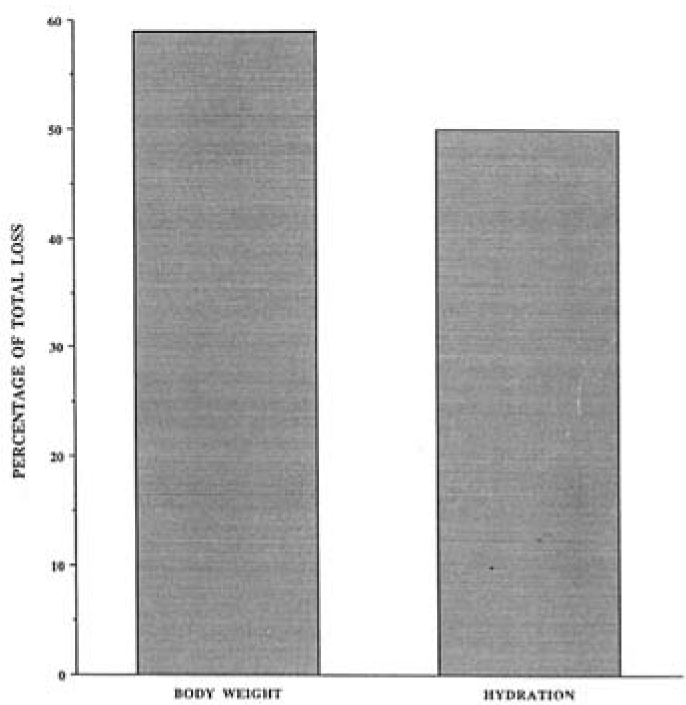


**FIGURE 17-2**
Body weight loss and change in hydration during deployment as a percentage of total change during an 11-d field training exercise.
SOURCE: Adapted from Popper et al. (1987).

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Beyond the specific consequences of deployment on energy or fluid balance and circadian rhythms, an important aspect of the field situation is the lack of time for adaptation. Soldiers typically go from their normal garrison situation to the field in a matter of hours where training can last for as little as a few days to as much as several weeks. Thus, for the soldier, the field situation is not only a complex environment, but one that is relatively unpredictable and into which he or she is thrust rather suddenly.

### Soldiers' Attitudes

Soldiers' attitudes about ration consumption will also be generally relevant to energy balance. For example, on any given field exercise, between 10 and 30 percent of soldiers report that they hope to lose weight while training in the field (Lester et al., 1989, 1993; Popper et al., 1987; Salter et al., 1991). Similarly, Special Forces' soldiers may deliberately choose to bring insufficient food for a mission and willingly lose weight rather than either have too much to carry or be forced to give up personal or operational items they perceive as essential. These kinds of individual-difference effects are not well documented, but the data are sufficient to conclude that weight loss can be seen as both positive (i.e., benefit) and negative (i.e., cost) and that the ration intake of soldiers will vary accordingly. Similarly, soldiers' health, religious, or other personal values will influence the perceived costs and benefits of ration consumption.

## Meal Timing

Soldiers, like most Americans, typically have ready access to a varied, affordable, and relatively tasty array of foods when they are in garrison (i.e., at their home base). They are well aware of what, where, and when food will be available, and mealtimes are a reliable and predictable event. During field exercises, however, mealtimes and their duration are irregular and often not predictable. Circumstances may impose an unexpected break for eating or, conversely, may interrupt or prevent a meal that soldiers were expecting to occur. A substantial body of human and animal research on issues related to meal timing exists that covers meal frequency, regularity and timing of meal schedules, and time permitted to eat. Selected aspects pertinent to military field feeding will be reviewed below.

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## Meal Frequency

Initial studies of meal frequency suggested that few, large meals tended to be more "obesifying" than more frequent but smaller meals (Fabry and Tepperman, 1970; Metzner et al., 1977). Although later work on meal frequency has weakened the proposed relationship between body weight and meal frequency (Adams and Morgan, 1981), recent findings confirm a metabolic advantage for more frequent meals for parameters such as blood glucose and lipid levels (Jenkins et al., 1989). If nutrient intake, particularly in large amounts, is viewed as a threat to homeostasis (Woods, 1991), then it is logical to see smaller meals that are anticipated by the organism as less costly in their metabolic demands and consequences.

## Meal Duration

Research has shown that insufficient time for eating is associated with a variety of deleterious consequences, including poorer consumption and greater loss of body weight, even in the presence of equivalent food intake. Kanarek and Collier (1983) and Lambert and Peacock (1989) found that animals permitted to eat for 60 min/d were unable to maintain food intake or body weight at normal levels particularly if the 60 minutes were given as a single block of time. Both studies also found that the failure to maintain body weight was exacerbated when the animals had access to a running wheel, which suggests that aside from the impact of increased energy expenditure or reduced time available for eating, higher levels of activity decreased the animals' ability to adapt to the meal schedule imposed upon them. For humans, the role of meal duration in food and body weight maintenance is unclear. Nonetheless, factors which promote larger meals such as eating with other people may influence intake by increasing meal length (de Castro, 1990).

## Meal Regularity and Predictability

Animal studies focused on the regularity or predictability of meals have consistently shown irregular schedules to be stressful and detrimental to metabolic patterns (e.g., blood glucose levels) and to be associated with poorer food intake and maintenance of body weight (Bazotte et al., 1989; Ulm et al., 1987; Valle, 1981; Welker et al., 1977). In humans, the consequences of irregular schedules are less clear (Moore-Ede and Richardson, 1985; Tepas, 1990), and the study of the effects of rotating shift-work schedules is methodologically difficult (Moore-Ede and Richardson, 1985). While inconclusive, the available data suggest that irregular schedules (as found for rotating shift workers) disrupt normal eating habits and are associated with less

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satisfaction with eating and with physical symptoms (e.g., gastrointestinal complaints) (Moore-Ede and Richardson, 1985; Tepas, 1990).

## Meals and Circadian Rhythms

At what time meals are eaten during the day appears to be relevant to food consumption and utilization. Several studies have indicated that metabolic responses and net energy balance differ as a function of the time of day food is eaten (Armstrong et al., 1981; Caviezel et al., 1981; Graeber et al., 1978; Halberg et al., Chapter 19 in this volume). These studies show that nutrients are utilized differently at different times of day, and therefore net energy balance will reflect not only total calorie intake but also when during the day calories are consumed. Both human epidemiological and laboratory studies also indicate that morning meals are typically smaller than those eaten at later times (Chao and Vanderkooy, 1989; Fricker et al., 1990; Kramer et al., 1992). In addition, Schutz (1988; Chapter 18 in this volume) has shown, as have others (Birch et al., 1984; Kramer et al., 1992), that people have clear standards for what foods are appropriate for a given time of day.

The stressful and less-energy-efficient nature of irregular meal times and lengths is consistent with the more general propositions discussed by Moore-Ede (1986) regarding reactive and predictive homeostasis. Reactive homeostasis is a response by an organism detecting a state of imbalance. Predictive homeostasis is more in line with Woods' (1991) discussion of behavioral tolerance. That is, organisms learn that certain events of physiological importance such as the opportunity to eat occur at certain times or are associated with other cues in the physical environment (time of day, a dining room, odors of cooking). Consequently, they use this learning to engage metabolic responses to optimize handling of the physiological challenges and utilization of ingested nutrients.

# Ration Aspects of the Field Situation

## Sensory Cues

Eating under normal conditions is associated with a large set of sensory cues that are markedly reduced when soldiers eat in the field. Given the packaging of operational rations in plain cardboard boxes and flexible retort[2]

[2] Retort pouches are opaque and flexible in nature. They are constructed of a trilaminate material consisting of polyethlylene as the food contact layer, a thin layer of aluminum foil, and polyester. Use of retort pouches for the Meal, Ready-to-Eat (MRE) and other rations are detailed in Darsch and Brandler (see Chapter 7 in this volume).

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pouches, soldiers have little opportunity for either the visual or olfactory cues typically associated with food or food preparation in nonfield environments. Similarly, as with most processed foods that have extended shelf life, operational rations have historically provided limited tactile or gustatory variety for the consumer. Sensory cues can add to or detract from the perceptions of foods and play a significant role in food choices and consumption (Mattes, 1987; Rolls, 1990; Warwick et al., 1993). Mattes (1987) notes that the impact of sensory stimuli on food intake is apt to reflect both the hedonic qualities and intensity of the stimuli. It is apparent that neither of these qualities can be optimal given the constraints (e.g., shelf-life requirements, cost) within which military food developers must operate.

Sensory cues appear to have a further impact on the metabolic utilization of ingested nutrients (Mattes, 1987; Powley and Berthoud, 1985; Woods, 1991) as a result of the physiological responses elicited by sensory stimuli. These cephalic-phase responses include such reactions as salivating after smelling the aroma from a bakery and less-visible responses such as changes in gastric secretion and insulin release. Rodin (1985) suggests that sensory stimuli and physiological responses may create a positive feedback loop. Sensory cues are associated with elevated blood insulin, for example, which in turn is associated with larger meal intake and increased ability to utilize ingested nutrients (Rodin, 1985; Woods, 1991). Fewer and less-intense sensory stimuli may result in lower intake of available rations due to decreased perceived desirability of the items and less-than-optimal utilization of the nutrients that are ingested. Thus the relative benefit of rations in an economic context is reduced in both the psychological and physiological realms. Lack of reliable sensory cues would also be apt to exacerbate the disruptions in anticipatory behavioral and physiological responses discussed previously (Moore-Ede, 1986; Woods, 1991).

### Ration Preparation and Use

A further cost of operational rations arises from the time and effort required for preparation and consumption. Such costs include the large number of packages to be opened and the difficulty of opening them (Kalick, 1991) and an historical lack of easy, quick, and militarily acceptable heating methods (Lester and Kramer, 1991).

Increasing response cost or degree of effort associated with eating has a long history of application as one of many techniques in the behavioral control of obesity or similar clinical problems (Brownell and Kramer, 1989). As described by Engell (Chapter 12 in this volume) and others (Meiselman et al., 1994), modest increases in effort to obtain beverages or food have marked effects on intake of those items. Durrant and Garrow (1982) studied subjects over a number of days in a controlled eating environment in which foods were

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obtained from a vending machine. Interestingly, when the "price" of more preferred food items was increased relative to other foods, subjects typically made compromises between choosing preferred foods and sufficient food to maintain energy intake. Although intake of the preferred foods decreased dramatically, subjects did not increase their intake of less-preferred items to the level necessary to maintain caloric balance. Similarly, Lappalainen and Epstein (1990) and Logue et al. (1990) have found that human subjects' willingness to work for food varied according to the desirability of the food, the relative effort needed to obtain it, and the availability of alternative behavioral choices (food and nonfood).

Initial results of the first field testing (Personal communication, K. L. Rock, U.S. Army Natick Research, Development and Engineering Center, Natick, Mass., 1993) of operational rations in packages designed to be easier to open indicated that soldiers in an active training scenario did find the new packages easier to open and liked them more overall than the standard packaging. Average consumption of the Meal, Ready-to-Eat (MRE) was also approximately 16 percent higher in the easier-to-open bag conditions. Soldiers in this test were fed one hot group meal a day in addition to being issued two MREs. Only MRE intake was assessed during this exercise. As a result, while the consumption results are intriguing, they do not represent total daily consumption, and further testing is needed to determine if easier-to-open packages will actually enhance total ration intake.

Reliable access to easy-to-use ration heating may also be viewed as improving the cost/benefit ratio of eating. Prior laboratory studies (Cardello and Maller, 1982; Zellner et al., 1988) have shown, as would be predicted, that foods are liked better when they are served at the expected temperature (e.g., hot coffee and hot main courses; cold fruit beverages). Field tests of rations also indicate that both ration acceptability and consumption are greater when soldiers can and do heat their food and beverages (Lester and Kramer, 1991). This study found enhanced consumption for the ration as a whole rather than only for the components designed to be heated, which suggests that heating had both direct effects (e.g., a hot entree is preferred and eaten more readily) and indirect effects (e.g., other food items were perceived as better, there was more time to eat the other ration components, etc.)

## Food Choice and Selection

The prepackaged nature of individual MREs and the overall ration limit soldiers' options regarding choices among foods as well as the amount of food they can consume. The current MRE (see Darsch and Brandler, Chapter 7 in this volume) contains 12 different menus and is packed in cases of 12 meals, including one of each menu. Limited choices among ration menus and items will increase the relative cost or, perhaps more accurately, reduce the perceived

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benefits of eating. Soldiers cannot readily rely on being able to choose their most preferred foods nor on being able to eat large amounts of one item at a meal in lieu of another (see below). The necessity of having preplanned, fixed menus also reduces the likelihood of soldiers finding meals containing items that are all well liked. Although soldiers trade with one another to obtain desired food components or voluntarily carry nonration items to the field, lack of choice will to some extent reduce variety, which may adversely affect consumption (see Hirsch, Chapter 9 in this volume). Studies have also shown that having a degree of control or choice over one's diet is generally associated with a more positive energy balance (Graeber et al., 1978; Pliner et al., 1980) and less dissatisfaction with repetitive menu plans (Kamen and Peryam, 1961). Research by Langer (1983) among others suggests that opportunities for control (both perceived and actual) by individuals improves a wide range of outcomes. Conversely, lack of control is deleterious (e.g., Seligman's learned helplessness [1975]).

Soldiers eating operational rations have minimal control over portion size as a strategy for optimizing food consumption and frequently report that ration portion sizes should be larger (Engell and Popper, 1988). Little research on portion size is available, and the findings are inconclusive regarding its impact on consumption (Booth et al., 1981; Edelman et al., 1986). However, field testing of versions of the MRE with 5- and 8-oz (143- and 229-g) entrees suggests that the MRE version with larger portions was linked to larger meal sizes and increased total daily intake over an 11-d period (Popper et al., 1987). In addition, intake records from field testing of rations indicate that soldiers consume approximately 95 percent of items that they begin to eat. These findings suggest that modest increases in caloric content of items consumed at high rates (e.g., entrees, desserts) could result in an increase in total consumption. For the soldier in the field, larger entrees or larger portions of selected items could permit a more flexible strategy for meeting energy needs at no additional cost for that individual. Future operational rations could also include this approach with or without adopting ration items and packaging that increase soldiers' eating options.

## The Eating Context

### Nonsensory Cues

In addition to the direct sensory cues associated with foods, eating is typically associated with a host of nonfood factors such as a dining room or cafeteria, dishes and silverware, sitting at a table to eat, and so on. In other words, a meal is an event or situation with specific parameters linked to its initiation and consumption (Weingarten, 1984). In the field, soldiers have few if any of these cues when consuming operational rations. Neither the research

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in this lab nor the literature generally provide clear-cut indications of the effects of these types of stimuli on food intake though their potential importance is evident. It is pertinent to note that behavioral treatment for clinical problems such as obesity place significant emphasis on reducing the nonfood cues associated with eating (Brownell and Kramer, 1989). For example, patients are instructed to eat in only one location in the house, to use a specific place setting for their meals, and to refrain from watching television or engaging in other activities while eating. Furthermore, conditioning studies with both animals (Detke et al., 1989; Weingarten, 1984; Woods et al., 1977) and humans (Cornell et al., 1989) have found that nonfood cues can effectively stimulate eating and metabolic response (e.g., insulin release) even after a full meal is consumed or without the actual presence of food stimuli. Such cues also play a prominent role in the anticipatory learning described by Woods (1991) and Moore-Ede (1986); lack of cues will be apt to result in less desire to eat and less behavioral and metabolic preparation to obtain and utilize foods.

## Individual Versus Group Rations

Although certainly not conclusive, studies of average energy intake of soldiers consuming two or more group meals per day (Figure 17-3) lend support to the idea that by increasing the soldier's ability to anticipate meals, to have more of the cues associated with eating a meal, and generally to increase the strategies or options open to the soldier, increased food consumption will be seen (King et al., 1992; Kramer et al., 1993; Salter et al., 1991). The larger meal sizes seen when soldiers eat rations designed for group feeding compared to those designed for the individual soldier also raise the possible role of socially mediated influences upon ration consumption.

De Castro (Chapter 20 in this volume) has shown repeatedly in recent work that people consume more food when eating socially than when eating alone. This *social facilitation* (Latane, 1981) effect is further supported by data collected during military training exercises (Hirsch and Kramer, 1993). Other studies have found a potentially powerful role for social influences such as modeling upon eating (Engell et al., 1990, Goldman et al., 1991; Polivy et al., 1979). Although certain social influences on eating are not situation specific (e.g., generally negative expectations for institutional products such as military rations), social facilitation as described by de Castro and any immediate effect of peers or others depend on having opportunities for these influences to take place. When soldiers are fed a ration designed for feeding groups, then opportunities for eating and interacting with fellow soldiers are much more probable. When soldiers consume individual operational rations such as the MRE, no explicit chance is given for meals to be social occasions.

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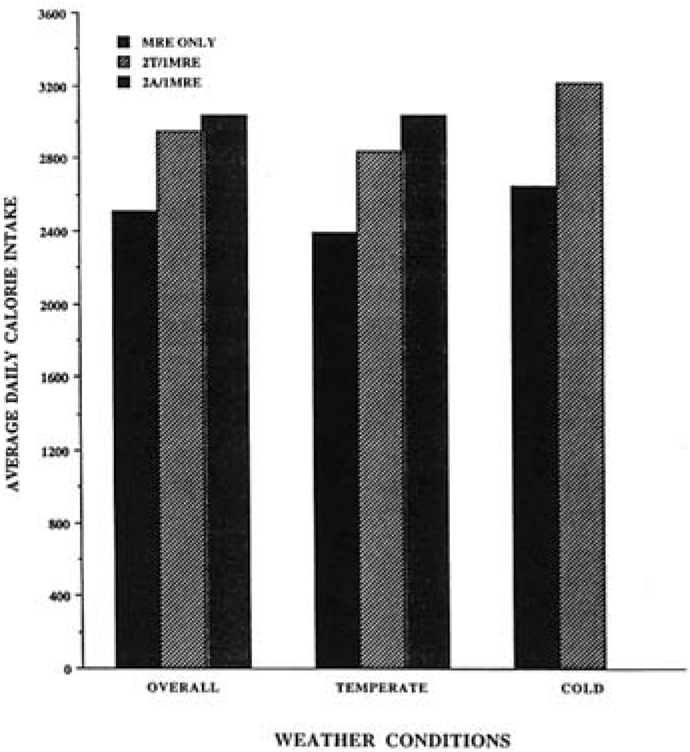


**FIGURE 17-3**
Average daily caloric intake for soldiers consuming only MREs, two T Ration meals and one MRE (2T/1MRE), or two A Ration meals and one MRE (2A/1MRE), in cold and temperate climates and overall.
SOURCE: Data adapted from Edwards et al. (1989), Engell et al. (1987), King et al. (1992), Lester et al. (1993), and Morgan et al. (1988) (cold); Askew et al. (1986, 1987), Hirsch et al. (1985, in press), Kramer et al. (1993), Popper et al. (1987). Rose and Carlson (1987), Salter et al. (1991), and USACDEC/USARIEM (1986) (temperate).

## SUMMARY AND RECOMMENDATIONS

Hirsch (Chapter 22 in this volume) describes a concept for demonstrating and testing approaches for improving ration consumption in the field. The goal of this chapter has been to make the point that the specific efforts described by Hirsch or suggested by others in this volume (e.g., Rolls, Engell, and de Castro, in Chapters 11, 12, and 20 respectively) are apt to be effective only to the extent that they give soldiers strategies to use in optimizing ration consumption or to improve the cost/benefit ratio of consumption behaviors.

The environment of actual combat situations or realistic training scenarios will likely preclude soldiers' ability to meet energy needs on a consistent basis. Nonetheless, it is apparent that military doctrine and commanders on the scene

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can apply methods to reduce ration underconsumption and waste. Similarly, changes in ration design, packaging, and variety can be used to increase soldiers' options for maintaining energy intake.

In conclusion:

- Despite current limits on scientific knowledge and restrictions inherent to combat field feeding, military planners, scientists, and commanders do have options for improving the "economics" of the feeding situation.
- Commanders and foodservice personnel frequently can improve the economics of the physical eating situation in one or more of the following ways: beverage and ration supply during deployment; when and how long soldiers can eat; ration type to maximize sensory and hedonic appeal and minimize preparation and effort to eat; feeding soldiers in groups rather than individually; and creating a more "meal"-like situation (e.g., serving food from tables, setting food up to enhance visual appeal, and soldier choice).
- Ration developers and scientists also can explore opportunities for improving feeding economics: increase ease of use through package design and preparation requirements; explore role of number and size of meal components; evaluate the value of rations in varying field contexts and relative to other factors related to overall quality of life (e.g., clothing and leadership); and examine the impact of time, sensory, or other cues associated with eating on nutrient intake and status.
- An economic viewpoint provides one method for creating an integrated approach to the development, study, and use of operational rations.

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## DISCUSSION

MARY MAYS: I may be asking a really obvious question. Has anybody tried taking the same amount of food and dividing it differently into meals? I am thinking of something like meal or an evening snack, something with sweet chocolate or maybe a separate sub-pack in each meal that could be carried and eaten throughout the afternoon.

Or is it, from a military discipline standpoint, really important to have food in three packs?

F. MATTHEW KRAMER: In one cold-weather study, there was the MRE plus a supplement. The supplement was located in a small pack, easy for soldiers to carry in their pocket, and eat whenever. In fact, it was supposedly designed so that soldiers could eat the supplement they were on the move. Phil Brandler, you may want to fill that in.

PHILIP BRANDLER: Yes. We tried something like that with good results in the cold-weather study in particular. But it was never adopted for whatever reason. The Quartermaster School decided that it was not a necessary addition. Therefore it never came into the system, despite the data.

Generally speaking, when soldiers get their MREs, they tear open the pack and stuff their pockets with whatever it is they want to eat later. Therefore, they are eating some items when they are ready. They might have crackers and jelly, M&Ms, or a chocolate bar in their packet. So, in a sense, they are not necessarily tied to eating times. They have some measure of freedom in terms of when they want to eat some items.

F. MATTHEW KRAMER: Except that I think the data show that soldiers eat at mealtime, and as Diane's data show, they drink at mealtime. The concept

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is that they can stuff their pockets and snack when ever they want to, but in fact, that does not happen as often as one might expect.

MARY MAYS: I saw something in Saudi Arabia that was very unusual. We came into an established group that had been given MREs for a long time, and we joined them and were also living on MREs for a long time.

We began to see a dramatic change in behavior. Where the soldiers had been snacking and eating at odd times, they suddenly began to gravitate together to eat. Someone would, "I am hungry; I am going to eat." And someone else would say, "Oh, you are going to eat. I will eat, too." Then someone would say, "Let's turn the fire on and actually heat this stuff." And we would turn the fire on, and we would find seven or eight people gravitating toward the tent,

That was a dramatic change in behavior, and this goes back to exactly what you are saying. The drinking went on at mealtimes, the eating went on at mealtimes, and it went on in groups.

Some soldiers stuck food in their pockets with the intention of eating it later and alone, but in fact they did not do so.

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# 18

# Eating Situations, Food Appropriateness, and Consumption

*Howard G. Schutz*[1]

## INTRODUCTION

In considering the factors that contribute to the underconsumption of foods, it is instructive to look also at the reasons that people do consume food. Table 18-1 shows the four basic factors that contribute to people consuming or not consuming foods. One basic dimension of consumption is *hunger or satiety*. Obviously people eat more or less depending on their perception of how hungry they are. This hunger is not necessarily related to physiological conditions associated with hunger or satiation at the stomach or cellular level, but rather to the individual's own perception of hunger. One could question whether in Western society one typically becomes truly hungry at the cellular level; nevertheless, the sensations of hunger and satiety are experienced, which motivates people to either eat or not eat.

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TABLE 18-1 Factors Influencing Consumption

| Why Do People… Consume? | Not Consume? |
|---|---|
| Hungry | Satiated |
| Availability | Unavailability |
| Like | Dislike |
| Appropriate situation | Inappropriate situation |

The second characteristic of consumption, *availability*, applies to food in general and also to the availability of specific items. Thus items that are unavailable because of seasonal variations or are out of stock in a store would contribute to nonconsumption of those items. In the military, food is only available that can be carried on one's back or supplied by a food service function.

The third characteristic of consumption, the *hedonic* feature of liking or disliking, has been given much attention in the food acceptance literature and has been used as the major predictor for whether or not foods will be consumed in both civilian and military populations (accounting for only about 50 percent of the variation in consumption).

The fourth and final factor of consumption is *appropriateness* or inappropriateness of the eating situation. In a broad sense this term covers all the aspects of the context in which food is eaten; thus ambient physical conditions, meal occasions, attitudinal states, and social environments can be included under this variable.

The dichotomous nature of consumption as shown in Table 18-1 is for illustrative purposes only. All of the factors are really on a continuum. The first three factors and all of the underlying conditions associated with them have received the greatest emphasis as predictors of consumption. Appropriateness is a relatively new factor in considerations of consumption, although researchers in the field have always qualified their results by indicating that to some extent the results were contingent on or confounded by the particular situation in which the measurement of both predictive and consumption variables were measured.

This chapter will analyze information from both consumer behavior research and from research on the cognitive and contextual aspects of eating, and determine to what extent this information can help create a better understanding of the factors that may contribute to underconsumption. In addition, some recommended ways to use this knowledge to improve consumption will be suggested.

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Table 18-2 summarizes the major situational influences on consumption. Note that under "antecedent state," sensory expectancy relates to an individual expecting a particular sensory experience from a food such as one that is spicy, mild, bitter, and so on. The extent to which the sensory expectancy is disconfirmed or confirmed could influence an individual's consumption of a particular food. Cardello's chapter (see Chapter 10 in this volume) covers this area in more detail. Also note under the heading "use occasion," that "purpose of product" is a general category, which includes such considerations as whether or not the product is, for example, a dessert or an appetizer; whether or not it is identified as being served for a particular meal occasion, such as for breakfast, lunch, or dinner; whether or not it fits a particular ethnic pattern; and so on.

## CONSUMER BEHAVIOR SITUATIONAL RESEARCH

The following discussion about consumer behavior situational research is by no means exhaustive; rather it is illustrative of the kinds of research done and data collected by consumer researchers in the food context area. Hugstad et al. (1975) had consumers report their preference for a variety of beverages with regard to various use contexts, as well as the attributes associated with each beverage. They also analyzed the results and grouped the beverages into context-specific ideal clusters. Table 18-3 summarizes their results. The beverages were grouped into four categories: water-based, hot adult, juices, and milk-based drinks. The use contexts included situational characteristics of physical state, meal, social situation, and time of year. The results shown in Table 18-3 indicate the quite logical nature of the attributes and types of drinks for different use contexts. One might infer that beverages served in an inappropriate use context, where their attributes did not fit, could be ones that

TABLE 18-2 Types of Situational Influence on Consumption

| | |
|---|---|
| Physical Surroundings | Temporal Perspective |
| • Geographical location | • Time of day |
| • Sounds | • Time since last event |
| • Aroma | Antecedent State |
| • Lighting | • Moods |
| • Weather | • Physical state |
| Social Surroundings | • Sensory expectancy |
| • Other persons present | Use Occasion |
| • Interpersonal interactions | • Purpose of product |
| • Roles | |

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would be underconsumed. For example, a hot adult drink would not be served during the summer if one expected to provide the attributes of sour, not relaxing, and thirst quenching.

TABLE 18-3 Use Occasion and Preference for Beverages

| Use Contexts | Context-specific Ideal Beverage Clusters | Attributes Closest to Context Ideal |
|---|---|---|
| During the summer | Water-based drink | Not relaxing, sour, thirst quenching |
| During the winter | Hot adult drinks | Served very hot, good for my health, energy giving |
| For breakfast | Juices | Primarily for children, good for my health, energy giving |
| For lunch | Hot adult drink | Served very hot, best with food, not thirst quenching |
| When friends come to dinner | Hot adult drinks | Primarily for adults, sour, light |
| When you are thirsty | Water-based drinks | Not relaxing, sour, thirst quenching |
| When you wish to relax | Water-based drinks | Relaxing, sweet, not thirst quenching |
| When you need a pick-me-up | Milk-based drinks | Served very hot, good for my health, energy giving |

SOURCE: Hugstad et al. (1975), used with permission.

Another example of the influence of situational conditions on food choice behavior is from the work by Miller and Ginter (1979) on fast food establishments. Table 18-4 presents percent of market share for eight different fast food establishments related to four categories of use occasions. Some restaurants such as McDonald's are deemed appropriate by customers for all four situations. Some have a low market share for all occasions, like Hungry Herman's, whereas others vary in their market share depending on the particular use occasion, such as Borden Burger and Wendy's. These data support the contention that there are large and important differences in the way in which consumers make choices (in this case choice of establishment), depending on the situation.

Belk (1975) has analyzed the effect of consumers, situations, and products on purchase behavior. In addition to the main effects, he examined the interaction among these three variables. The data in Table 18-5 show that situations play a smaller role than products in accounting for the purchase behavior of the four product categories. Nevertheless, in this study the statistical

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TABLE 18-4 Competitive Dynamics, as Shown by Percent Market Share, Among Fast Food Restaurants by Type of Use Occasion

| | Percent Market Share of Customers Who Consume… | | | |
|---|---|---|---|---|
| Establishment | Snack While Shopping | Lunch | Evening Meal When Rushed | Evening Meal with Family, Not Rushed |
| White Castle | 14 | 8 | 0 | 5 |
| Wendy's | 13 | 13 | 13 | 21 |
| McDonald's | 35 | 27 | 33 | 38 |
| Hungry Herman's | 1 | 3 | 2 | 3 |
| Burger King | 14 | 14 | 15 | 12 |
| Burger Chef | 4 | 9 | 4 | 5 |
| Borden Burger | 13 | 18 | 18 | 10 |
| Arby's | 4 | 4 | 4 | 3 |

SOURCE: Adapted from Miller and Ginter (1979).

TABLE 18-5 Effects of Situations, Products, Persons, and Interactions on Consumer Behavior

| | Response Category (%) | | | |
|---|---|---|---|---|
| Source | Beverage Products | Meat Products | Snack Products | Fast Foods |
| Consumers (C) | 0.5 | 4.6 | 6.7 | 8.1 |
| Situations (S) | 2.7 | 5.2 | 0.4 | 2.2 |
| Products (P) | 14.6 | 15.0 | 6.7 | 13.4 |
| S x P interaction | 39.8 | 26.2 | 18.7 | 15.3 |
| S x C interaction | 2.7 | 2.9 | 6.1 | 2.2 |
| P x C interaction | 11.8 | 9.7 | 22.4 | 20.1 |
| Residual | 27.8 | 36.4 | 39.0 | 38.7 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |

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situation x product interaction accounts for a larger percentage of the responses than any of the individual product categories. Clearly, trying to understand purchase behavior on the basis of the product alone without regard to the situation provides a very weak understanding of consumer behavior.

## FOOD COGNITIVE-CONTEXT RESEARCH

A number of studies conducted by food researchers in the cognitive area point to the importance of understanding food consumption by using appropriateness measures. Schutz (1988) described the general concept of appropriateness as an aspect of food attitudes that makes a significant contribution, independent from food preferences, to the understanding of food behavior. In one study 200 females, 50 each in four cities across the country, evaluated 56 foods with regard to their appropriateness for 48 uses-attributes (Schutz et al., 1975). They used a 7-point appropriateness scale anchored by the terms "never appropriate" and "always appropriate." The food items are shown in Table 18-6 and the uses in Table 18-7. The foods cover a wide range of food classes and all types of situational influences. One of the purposes of this study was to demonstrate the cognitive structure of foods based on the perception of "use appropriateness" rather than by typical food classes developed by food technologists, nutritionists, or anthropologists (e.g., dairy, meat and fish, fruits and vegetables, cereals and grains). To accomplish this objective, the foods were analyzed as variables in a principle component analysis (PCA), with the mean ratings for all uses as the cases.

Table 18-8 summarizes the results of the PCA where the four factors extracted are named and the five highest rated uses are given in order of their factor weights. From this analysis one concludes that appropriateness does allow for a meaningful categorization of foods, which incidentally does not correspond to any of the standard food classifications.

Table 18-9 rank orders the five most appropriate foods on the five PCA dimensions. These were found by analyzing the uses as variables, with food products as cases, and with the addition of "really like" as a representation of the hedonic component for these foods. The names for the factors were derived from the highest-rated attribute in each of the use factors. This table shows that knowing the basic liking order for foods does not necessarily provide information on the most appropriate use situation for foods. Thus, it seems reasonable that items served for an inappropriate use situation would be less likely to be consumed than those served in an appropriate situation. For example, although steak might be very well liked, it is not likely that it would be purchased and consumed when one was looking for an inexpensive food.

Another similar study was conducted in United Kingdom by this author and colleagues from the Institute of Food Research at Reading, England (Shepherd et al., 1992). In this case there were 50 foods and 50 uses-situations.

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TABLE 18-6 Food Items Rated by Women in a Four-City Study

| Food Items | |
|---|---|
| Pie | Yogurt |
| Potato Salad | Roast beef |
| Milk | Spaghetti |
| Tomatoes | Fried eggs |
| Chicken | Green salad |
| Coffee | Orange juice |
| Jell-O | Ice cream |
| American Cheese | Baked beans |
| Shrimp | Rice |
| Tea | Carrots |
| Chili | Bagels |
| Vegetable soup | Broccoli |
| Liver | Cottage cheese |
| Fish | Peanut butter |
| Soft drinks | French fries |
| Meat loaf | Ham |
| TV dinners | Peas |
| Watermelon | Strawberries |
| Steak | Potato chips |
| Wine | Tuna |
| Dry cereal | Pizza |
| Cake | Hot dogs |
| Dip | Pickles |
| Chop suey | Onions |
| Apples | Parsley |
| Chitterlings | Candy bars |
| Bread | Bacon |
| Hamburger | Tacos |

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TABLE 18-7 Uses/Situations for Rating Foods in a Four-City Study

| Food Uses | |
|---|---|
| Have to lose weight | When eating out in a restaurant |
| Want something easy to chew | Want something light |
| To eat with a spoon | With coffee |
| For teenagers | When riding in a car |
| For dessert | To eat with fingers |
| Want something inexpensive | For men |
| Want something nutritious | On cold days |
| When don't have much time to eat | When visiting someone |
| For breakfast | In a salad |
| For special holidays | When really hungry |
| In the summer | A spicy food |
| In a sandwich | For children |
| For guests | Served cold |
| Want a variety in meals | To eat with a fork |
| For a sack lunch | Easy to digest |
| At parties | With cocktails |
| For a between-meal snack | When want something really like |
| With friends | Just itself |
| For lunch | Want something easy to prepare |
| When want to feel creative | On a picnic |
| When not very hungry | Something you broil |
| When I am unhappy | Something you try not to run out of |
| As a main dish | When not feeling well |
| For dinner | When watching TV |

SOURCE: Schutz et al. (1975), used with permission.

The respondents, 25 males and 25 females chosen at random from the Reading area, rated the appropriateness of each of the foods for each of the uses-situations on the same 7-point appropriateness scale, and in addition they gave information on the frequency of consumption of each of the items in times per day, week, or month. Respondents also rated the importance of six considerations

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when choosing foods—taste, price, health, weight control, nutrition, and other people's views. Table 18-10 lists the 50 uses-situations. The mean frequency per month of each of the 50 foods is given in Table 18-11. Although frequency evaluations of dietary intake are open to some criticism, there is evidence for the sufficient validity of such measurements to make them worthwhile as a measure of general patterns of consumption rather than for nutritional information. In addition the data collected have a reasonable level

TABLE 18-8 Rank Order of Factor Loadings for 5 Highest Weighted Uses from Factor Analysis of 48 Uses

| | |
|---|---|
| I Utilitarian | II Casual |
| For teenagers | When unhappy |
| For children | Riding in a car |
| Easy to prepare | For dessert |
| In summer | With cocktails |
| For men | Eat with a spoon |
| III Satiating | IV Social |
| As a main dish | At parties |
| Eat with a fork | With friends |
| For dinner | For guests |
| Really hungry | For special holidays |
| | Don't run out of |

SOURCE: Schutz (1988), used with permission.

TABLE 18-9 Rank Order of 5 Highest Appropriateness Means for Factor Representative Uses and Preference for 56 Foods

| | | |
|---|---|---|
| **I Really like** | **II For teenagers** | **III Unhappy** |
| Steak | Ice cream | Coffee |
| Roast beef | Milk | Tea |
| Salad | Hamburger | Wine |
| Strawberries | Pizza | Ice cream |
| Spaghetti | Jell-O | Strawberries |
| **IV As a main dish** | **V At parties** | **VI Inexpensive** |
| Roast beef | Dip | Jell-O |
| Steak | Potato chips | Hamburger |
| Chicken | Coffee | Spaghetti |
| Spaghetti | Wine | Vegetable soup |
| Meat loaf | Cake | Meat loaf |

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of face validity. Similar to the earlier study (Schutz et al., 1975) conducted in the United States, a PCA was done on both foods and attributes. The food PCA will not be discussed here except to say that it was a more complex result than in the U.S. study, which could be due to either the difference in the United Kingdom versus United States populations or to the 15-year difference in the time the studies were conducted. The attribute PCA for the United Kingdom also resulted in more factors, in this case, 10. As in the U.S. study,the single attribute that was most heavily weighted on each of the factors was used to represent that use factor. These 10 were, in order of their contribution to the variation of the data:

TABLE 18-10 Uses/Situation For Rating Foods in United Kingdom Study

| | |
|---|---|
| When I want something inexpensive | Low in salt |
| When I want something I really like | For a between meal snack |
| Low in calories | When I am very hungry |
| A food I spend time thinking about | When I want something different |
| In a sandwich | A food with which I am very involved |
| For frying | For a packed lunch |
| For breakfast | When I want value for money |
| When I don't want a lot of cleaning up | When eating in a restaurant |
| For grilling | When I am not feeling well |
| For when I eat alone | Served cold |
| A food I feel strongly about | For lunch |
| As a main dish | High in fiber |
| Low in fat | At parties |
| Just by itself | A food not to run out of |
| A food with a consistent quality | A food always available in the shops |
| For guests | When I am unhappy |
| A food difficult to resist | For children |
| To eat with a fork | When I want something nutritious |
| For men | For dessert |
| For dinner | To cook in a microwave oven |
| For women | When I want something spicy |
| A food that freezes well | Something I can prepare in many ways |
| When I want something easy to prepare | When I want to feel creative |
| To eat with my fingers | In the summer |
| When watching television | On cold days |

- When I want something I really like
- When I don't want a lot of cleaning up
- A food not to run out of
- Low in calories
- At parties

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- When I want something spicy
- In a sandwich
- High in fiber
- For dessert
- A food that freezes well

To determine the relative importance of demographics, appropriateness (representatives of the 10 use factors given above), and other attitude data related to frequency of consumption, a series of stepwise multiple regression

TABLE 18-11 Mean Frequency of Consumption per Month in United Kingdom Study

| Food | Average per Month | Food | Average per Month |
|---|---|---|---|
| Tea | 103.32 | Chips | 5.34 |
| Milk | 72.15 | Wine | 5.26 |
| Coffee | 61.67 | Bacon | 4.50 |
| Skimmed milk | 46.27 | Ham | 4.34 |
| Bread | 44.65 | Ice cream | 4.27 |
| Butter | 29.84 | Pasta | 4.01 |
| Wholemeal bread | 28.05 | Fried eggs | 3.24 |
| Biscuits | 22.99 | Broccoli | 2.99 |
| Breakfast cereal | 18.95 | Frozen meals | 2.92 |
| Orange juice | 18.14 | Sausage | 2.85 |
| Cheddar cheese | 15.09 | Bacon and eggs | 2.75 |
| Apples | 13.19 | Fruit cake | 2.13 |
| Soft fizzy drink | 12.24 | Fish and chips | 2.01 |
| Crisps | 10.88 | Vegetable soup | 1.98 |
| Tomatoes | 9.99 | Curry | 1.76 |
| Yogurt | 9.41 | Steak | 1.31 |
| Chocolate bars | 9.28 | Roast beef | 1.25 |
| Peas | 9.05 | Cottage cheese | 1.21 |
| Carrots | 7.25 | Pizza | 1.19 |
| Green salad | 6.79 | Liver | 1.07 |
| Chicken | 6.06 | Hamburger | 1.03 |
| Baked beans | 5.88 | Prawns | 0.92 |
| Beer | 5.70 | Strawberries | 0.84 |
| Fish | 5.44 | Pork pie | 0.64 |
| Rice | 5.43 | Chop Suey | 0.39 |

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correlation coefficients were computed. This was done over all foods and for each individual food. Table 18-12, presents the results for five representative foods and for all foods combined. For all 50 of the foods it was possible to find a statistically significant relationship between a set of independent variables and the dependent variable of frequency of consumption. However, there was a wide range in the amount of variance that could be predicted. Examining Table 18-12 reveals that although the "really like" variable can be found in a variety of equations, it is not always there, and it is not alone in its ability to predict consumption. The data support the contention that in order to understand consumption or underconsumption, it is important to know more

TABLE 18-12 Selected Multiple Regressions Predicting Frequency of Consumption from Demographics, Appropriateness, and Food Considerations

| Food | $R^2$* | Variable and Partial Correlation | |
|---|---|---|---|
| Pasta | .33 | Really like | .53 |
| | | Nutrition importance | .40 |
| | | Weight | -.38 |
| | | For dessert | -.34 |
| | | Gender | -.33 |
| | | Available | -.22 |
| Fruit cake | .44 | Other people importance | .63 |
| | | For children | -.49 |
| Skimmed milk | .48 | Really like | .64 |
| | | Weight | .41 |
| | | Taste importance | -.24 |
| Bacon | .62 | Really like | .61 |
| | | Health importance | -.52 |
| | | For children | -.65 |
| | | Other people importance | .52 |
| | | Gender | -.46 |
| | | Weight | -.35 |
| | | Weight control importance | -.33 |
| | | Nutrition importance | -.23 |
| Bread | .44 | For low calorie | .56 |
| | | Socioeconomic class | .34 |
| | | Available | -.49 |
| | | Taste importance | .40 |
| | | When alone | .31 |
| | | For sandwich | .28 |
| | | Weight | -.23 |
| All foods | .73 | Available | .83 |
| | | For low calorie | .51 |
| | | Freezes | -.30 |
| | | Average involvement | .25 |

* *R2* = Multiple correlation coefficient.

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than just whether or not a food is liked. Note also that for some foods, a large amount of variation in frequency of consumption can be accounted for if one includes other than affective information.

As one way of gauging the relative importance of the independent variables contributing to the equations, the numbers in each of the five categories of independent variables were counted and are shown in Table 18-13. The first category "appropriateness" accounts for the largest percentage of variables included in the analyses; one component "really like" of appropriateness alone contributed 12 percent. The demographics consisted of such variables as age, gender, and so on. "Considerations" were the six food considerations mentioned earlier. Average involvement was a variable computed by averaging three attributes that were designed to measure degree of involvement with foods, and average appropriateness was simply the average for a food over all situations.

The involvement scale is an interesting one. In this author's opinion, involvement represents a missing link in the explanation of why attitudes do not predict behavior to a greater degree than has been found in most research studies. It appears from consumer behavior research that some attitudes toward food or other goods are indicated by respondents when they are asked the questions, not because they consider them relevant, but simply because they feel it is appropriate to respond. The consumer behavior literature has recognized this factor (Wilkie, 1990), and for the past 10 years researchers have been actively measuring involvement as an intermediate variable in helping to explain the nature of purchase and of consumption of goods and services.

TABLE 18-13 Summary of Variables in Multiple Regression Prediction of Frequency of Consumption

| | *N* | % |
|---|---|---|
| Appropriateness* | 114 | 43 |
| Demographics | 67 | 26 |
| Considerations | 63 | 24 |
| Average involvement | 12 | 5 |
| Average appropriateness | 6 | 2 |
| Total | 262 | 100 |

* For "really like" component, *n*=31; % = 12.

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## Laboratory Appropriateness Studies

Kramer et al. (1992) conducted a study on the effects of time of day and appropriateness on food intake and hedonic ratings with 19 male employees of the U.S. Army Natick Research, Development and Engineering Center. Thirty-six representative breakfast and lunch foods were rated for acceptability by the 19 respondents when the foods were served for breakfast or lunch. The 19 subjects were given foods that they had been rated high and low in appropriateness for each of the meal occasions. They rated their hunger and each food item on a hedonic scale before and after each meal. Although food items were rated higher for appropriate meals, consumption was actually greater for lunch items that were served for breakfast, with hedonic ratings during meals equal to ratings before meals. However, hunger rated lower after inappropriate meals. Although this study seems to indicate that inappropriate foods for particular meals do not result in lowered consumption, perhaps the 2-wk time period involved in this study was not long enough to overcome what might be considered a novelty effect. The fact that hunger was rated lower after inappropriate meals may be a clue to the eventual result that foods that are particularly inappropriate for meal occasions would be consumed at a lower level.

Recently Armand Cardello and this author began a series of appropriateness studies in a laboratory panel situation. The purpose of the studies is to examine the potential contribution of appropriateness type data obtained on taste test samples as an adjunct to the standard hedonic acceptance data. Ten situations were selected to represent basic situation components, and a ballot form was prepared for each food to be rated. During standard panel acceptance studies, respondents rated the foods they received on the 10 situation scales using the 7-point appropriateness scale (in addition to the 9-point hedonic rating scale). The ratings on appropriateness occurred during the waiting period between taste test samples.

Two tests illustrate the type of results that have been obtained. Figure 18-1 shows the mean appropriateness ratings for three meat products on the 10 scales and also the mean acceptance ratings for the three products. The three products did not differ significantly on mean acceptance. However, there is a significant difference for two of the appropriateness scales: "for breakfast," where the baked ham is more appropriate than the roast veal or pork adobo products, and for "when I want something different," where the baked ham is significantly less appropriate than the other two products. As might be expected for the other attributes since these are all main dish items, there is a high degree of similarity in the response profiles for the three products.

Figure 18-2 shows the mean appropriateness ratings for stuffed cabbage roll, baked ham, and a spaghetti product. Again, there are no significant differences in the mean acceptance ratings, however there are significant differences for four of the situation appropriateness variables: "for breakfast,"

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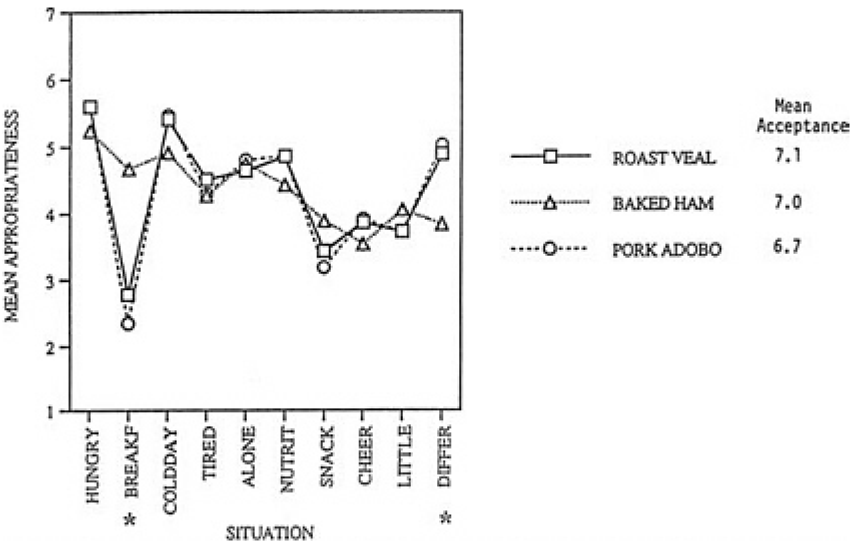


**FIGURE 18-1**

Summary of mean appropriateness ratings for a veal, ham, and pork product. *,$P < 0.5$; "cheer," when I want cheering up; "little," when I have little time to eat; "differ," when I want something different.

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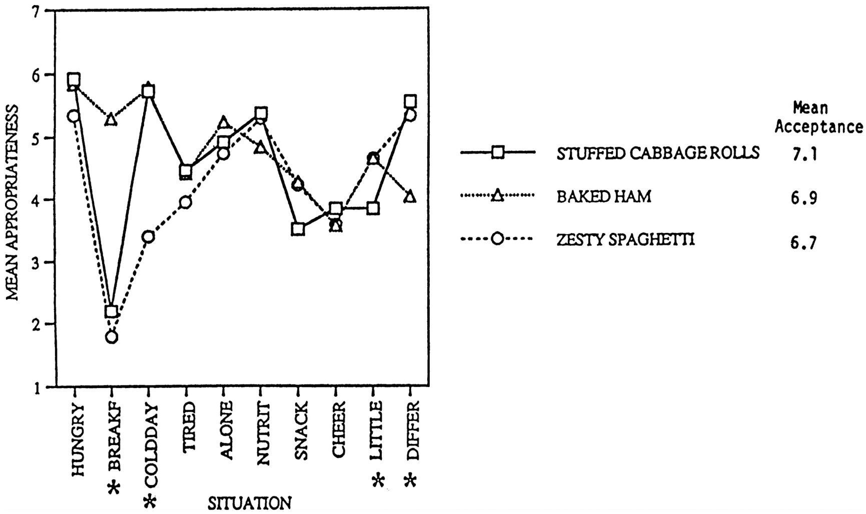


**FIGURE 18-2**

Summary of mean appropriateness ratings for cabbage rolls, ham, and spaghetti products. *,$P < 0.5$; "cheer," when I want cheering up; "little," when I have little time to eat; "differ," when I want something different.

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"a cold day," "when there is little time to eat," and "when I want something different." Whereas the baked ham is considered quite appropriate for breakfast, the spaghetti and stuffed cabbage rolls are definitely inappropriate for this meal occasion. "On a cold day," spaghetti is less appropriate than the other two products, and "when you have little time to eat," the cabbage roll is less appropriate. For a product that is considered "different," baked ham is less appropriate than the other two products. For these three products, the two meat-based products have more similar profiles, whereas the spaghetti product represents a slightly different profile, which is not an unexpected result.

Together these two examples illustrate the ability to extend the appropriateness procedure to an actual food-tasting situation and the value of the data collected by such a procedure. The fact that these products do not differ in acceptance might have lead one to believe that they would be equally acceptable for a variety of serving situations. This is obviously not the case, and data such as these could prove useful as an early screening procedure in the development of products for the military.

## DISCUSSION

The information presented on appropriateness and consumption makes it clear that food item and situation interaction are important and can influence consumption and therefore underconsumption. Certainly level of appropriateness may operate differently in some circumstances in the commercial civilian world than it does in the military world. Availability operates quite differently in the civilian versus the military world. In the civilian world availability may be a function of time of year, location of stores, and cost of products. In the military, in contrast, limitations in availability can be a function of time available to prepare food and methods of distribution that fit the particular military situation. Availability and situation may interact in the military more strongly than in the civilian sector. For example, when only less-appropriate foods are available, they still may be eaten in the military, but will not be in the civilian sector. The reasons one might influence the selection or availability of particular items for the military or civilians might differ, but it should be possible to do a better job of matching particular foods to particular situations in the military and vice versa. Although the data and ideas described in this chapter were based on civilian respondents, there is no reason to believe the same type of information would not be found in the military population.

It is easy to measure the food acceptance ratings of products under development and assume that they are reasonable predictors of actual consumption. However, in reality, this is not the case. At least one important aspect of predicting consumption should include the appropriateness of the item for the particular profile of situations that are most likely to occur for that product.

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## CONCLUSIONS AND RECOMMENDATIONS

Preference is not the same as appropriateness, although the two are related. If a product is not appropriate for any situation, it is probably one that is not liked at all. On the other hand, a product that is appropriate for many situations is probably one that is generally liked.

Underconsumption cannot be predicted by food acceptance data alone, and appropriateness is an important predictor of frequency of consumption. It therefore may be helpful in understanding underconsumption. Specific "military appropriateness situations" and interactions of the person, the product, and the situation should be studied.

Appropriateness measurement should be part of the screening process in ration development in both laboratory and field tests. Specifically, the influence of item selection and situation on consumption in the military should be studied further.

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## DISCUSSION

RICHARD JANSEN: There have been a lot of comments made about what food should be eaten at a meal, and particularly at regular meals, in some of the other studies that Howard Schutz has been taking about.

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This is not my area of research, but I have the impression that what has happened culturally in this country is a movement away from meals toward "grazing." Not only that, but the family mealtime has had to become less important. And it seems to me that this is somewhat at variance with what I have been hearing here.

HOWARD SCHULTZ: Let me make a comment about that. You are right and you are wrong. You are right, I think, in that in the commercial world we do a lot more grazing and there are a lot less formal meals. But I think that in that in the situation in the military, there is a stress situation. I think people tend to go back to more secure ways of doing things.

I think it is probably less likely they would behave in that way under those circumstances. That is why I say we have to look at the specific military situations, not just the situation generalized from the civilian one.

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# 19

# From Biologic Rhythms to Chronomes Relevant for Nutrition

*Franz Halberg,[1] Erhard Haus, and Germaine Cornélissen*

## INTRODUCTION

Any one physiologic variable is characterized by a spectrum of rhythms that are genetically anchored, socioecologically synchronized (by the cycles of an environmental niche), and influenced by heliogeophysical effects. Influences can be objectively quantified in terms of cross-spectral coherences. Synchronization is studied (e.g., by shifts of meal timing, such as on shift work, and/or the entire daily routine, such as after transmeridian flights) when different chronome components may adjust at differing rates in any one variable. Blood pressure and heart rate, for instance, reveal a slow adjustment of a built-in approximately 7-d rhythmicity in the face of a rather rapid adjustment of the circadian component in the same variables. Shifts in meal timing have different effects upon different physiologic variables and thus alter internal relations among rhythms at different organization levels, as documented for the

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circadian chronome components of humans and rodents (Figures 19-1, 19-2, and 19-3).

## MEAL TIMING IN TERMS OF CALORIES AND SEDENTARY LIMITED MOTOR ACTIVITY

It seems possible to better exploit what is being eaten by scheduling meals. Food consumption could be scheduled for a time when it is physiologically (Goetz et al., 1976; Halberg, 1983, 1989; Halberg et al., 1976, Hirsch et al., 1975; Jacobs et al., 1975) and logistically most useful for body weight maintenance. Specifically, as a countermeasure in the face of underconsumption of rations by workers in the field (such as soldiers), at least one meal should be timed by taking into account the studies carried out in Minnesota on meal timing (Goetz et al., 1976), some of them sponsored by the U.S. Army Institute of Environmental Medicine and the U.S. Army Natick Research, Development and Engineering Center (NRDEC) (Hirsch et al., 1975; Jacobs et al., 1975). These investigations, which compare a single daily meal consumed as a breakfast versus one eaten as a dinner, clearly show a relative

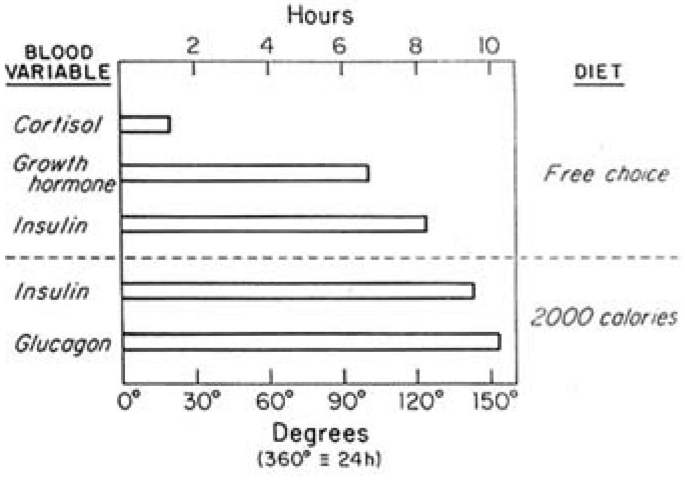


**FIGURE 19-1**
Differential displacement of circadian hormonal timing as a result of changing a single daily meal from breakfast to dinner. Whereas the circadian rhythm of circulating cortisol is only slightly affected by the timing of a single daily meal, considerable phase-shifts are observed for the case of growth hormone, insulin, and glucagon. SOURCE: © Franz Halberg (1970), used with permission.

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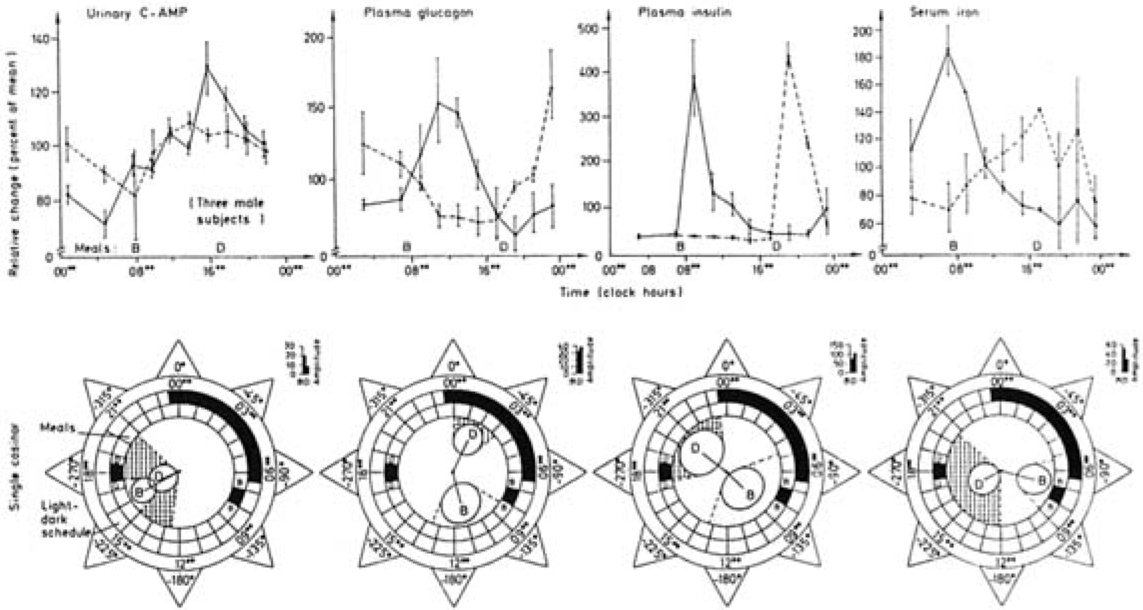


**FIGURE 19-2**
Consuming a single daily meal as breakfast only versus dinner only affects the timing of the circadian chronome component differently for different physiologic variables in humans. The single daily meal was 2,000 kcal given for 7-d spans. Breakfast (B), solid line. Dinner (D), broken line.
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gain in body weight at dinner only versus breakfast only (a statement equivalent to that of a relative body weight loss on breakfast only versus dinner only) (Figures 19-4, 19-5, 19-6, and 19-7). Since in these studies physiologic and psychologic performance were investigated, as were metabolic and endocrine variables, a first recommendation is the completion of analyses of these data (Goetz et al., 1976; Halberg, 1983, 1989; Halberg et al., 1976; Hirsch et al., 1975; Jacobs et al., 1975) on the consequences (concerning body weight and other physiologic and psychologic performance) of consuming one single large meal within 1 hour of awakening (breakfast only) or not before 12 hours after awakening (dinner only). A second recommendation is to extend the scope of the paradigm tested earlier concerning a single meal per day, with several scenarios applied to The Meal, Ready-to-Eat (MRE).

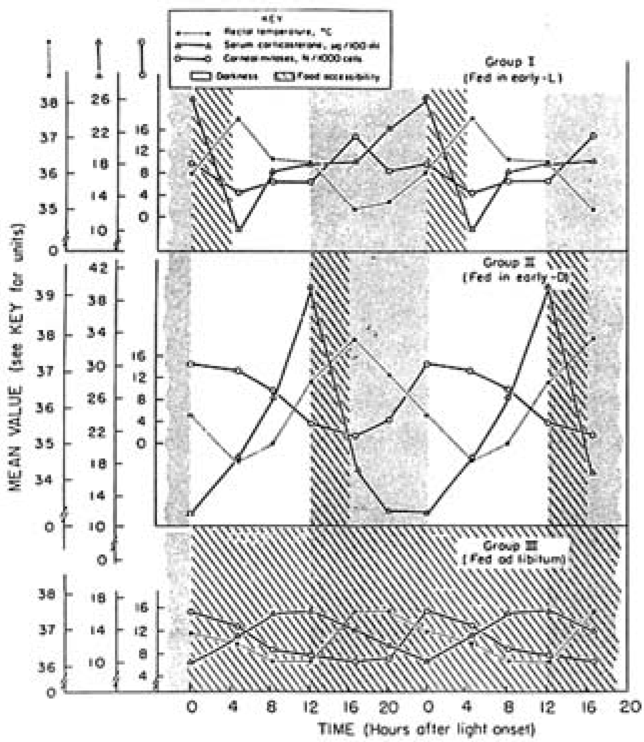


**FIGURE 19-3**
Effects on circadian rhythmic variables in mice of different lighting schedules, early light phase (early-L) and early dark phase (early-D),
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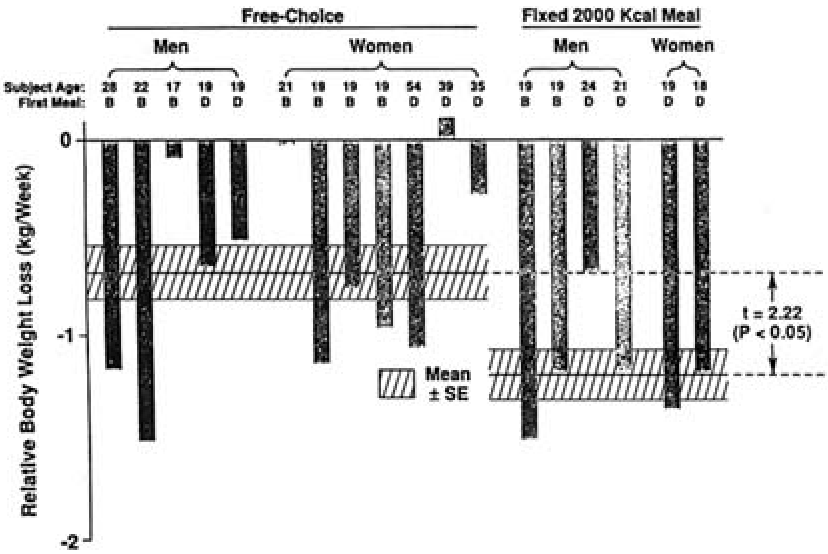


**FIGURE 19-4**

Meal timing and body weight. In two separate studies of the effect of meal timing on body weight, nine men and nine women consumed either a fixed 2,000 kcal meal or a single free-choice meal as breakfast (B) or dinner (D) (for 1 week on a fixed-calorie meal or 3 weeks on a free-choice meal). Body weight remained more or less unchanged on dinner only; a decrease of about 1 kg/wk was noted on breakfast only. The rate of body weight change also differed significantly ($P < 0.01$) between the two schedules.
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## Timing the Kinds of Calories

Specifically, if one had the means, one should repeat the single meal per day study with and without exercise while concomitantly varying the proportions of carbohydrate, fat, and protein, both in the absence of snacks and then with the stepwise systematic addition of timed snacks. With more modest resources, the next step should be tests in the field with exercising and nonexercising individuals consuming three MREs as breakfast, lunch, and dinner versus consuming one-half of an MRE for breakfast, the other one-half MRE for lunch, and two MREs for dinner.

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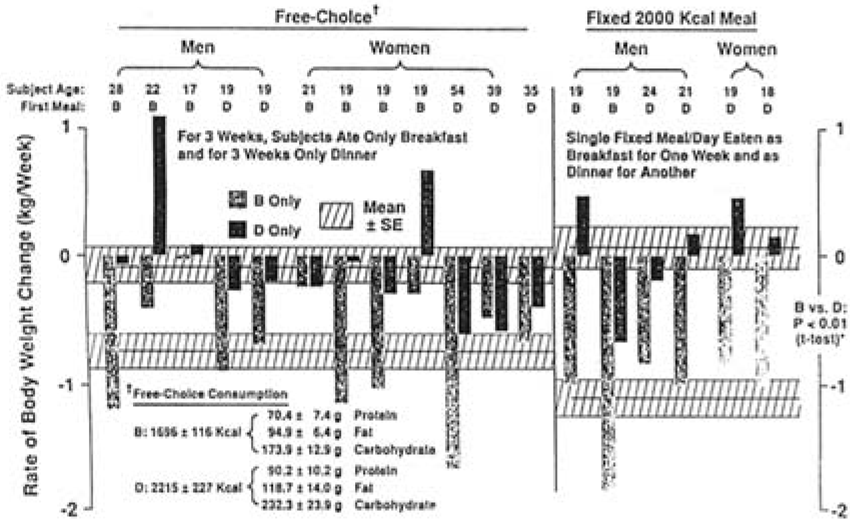


**FIGURE 19-5**

Relative body weight loss on breakfast only versus dinner only for each subject participating in the two studies described in Figure 19-4. Only one volunteer gained weight on breakfast versus dinner. Overall, the difference in relative body weight loss on breakfast (B) versus dinner (D) is statistically significant ($P < 0.05$), whether a fixed 2,000 kcal meal or a single free-choice meal is consumed.

Weight change (kg/wk) on D subtracted from that on B. In the study on one free-choice meal per day, subjects are only breakfast for 3 weeks and only dinner for 3 weeks. In the study on one fixed 2,000 kcal meal per day, subjects ate only breakfast for 1 week and only dinner for 1 week. Note that mean relative weight loss is greater on fixed than on free-choice meal.

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## Meal and Performance Timing

In view of a circadian rhythm in the response to exercise (Halberg et al., 1988; Levine et al., 1977), any effect of meal timing on performance could be assessed by having the exercising group complete a standardized routine, for example on a bicycle ergometer. The routine could be repeated at 3-h intervals; at awakening; at 3, 6, 9, and 12 hours thereafter; and at betime. This lab has tested on four subjects a more rigorous schedule, namely exercise at 7 a.m., 10 a.m., 1 p.m., 4 p.m., 7 p.m., 10 p.m., and 1 a.m. each day for up to a month. It would be important to concomitantly evaluate mental performance and alertness on the different schedules. Several studies in his lab have shown that body weight loss may not necessarily be accompanied by a decrease in performance.

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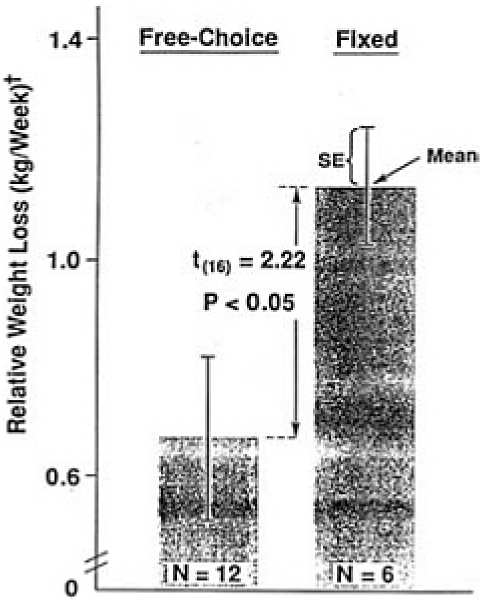


**FIGURE 19-6**

Appetite (here defined as choice and amount of food) modifies the effect of meal timing on body weight. Relative body weight loss on breakfast only (B) as compared to dinner only (D) is less when meal is free choice rather than fixed. Therefore, to minimize body weight loss when a single meal is consumed, it may be preferable not to fix the ration but to offer a choice.

An overall summary of relative body weight loss on breakfast only versus dinner only in the two studies described in Figures 19-4 and 19-5 indicates that the decrease in relative body weight was more pronounced when a fixed 2,000 kcal meal was imposed than when volunteers could choose what they ate. †, weight change (kg/wk) on B subtracted from that on D.

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## Meal Timing and the Body's Time Structure (Chronome)

The Minnesota-Natick studies (Goetz et al., 1976; Halberg et al., 1976; Hirsch et al., 1975; Jacobs et al., 1975) have shown that meal timing is a way to shift physiologic rhythms and that it may amplify the expression of the circadian system, as do certain drugs such as acetyl-L-carnitine (Cornélissen et al., 1992; Portela et al., 1993). It would be worthwhile to determine the most favorable configuration of rhythms in order to assure the peak alertness and performance (e.g., of rangers or pilots) during the most critical times of duty, even if these schedules may be associated with some body weight loss, notably in situations where field duties are of limited duration. Note that at least in the experimental laboratory, food restriction (e.g., to 70 percent of what is consumed ad lib) is associated with a prolongation (Nelson and Halberg, 1986a, b), not a shortening, of the lifespan and also with a lower incidence of mammary cancers (Halberg et al., 1986b).

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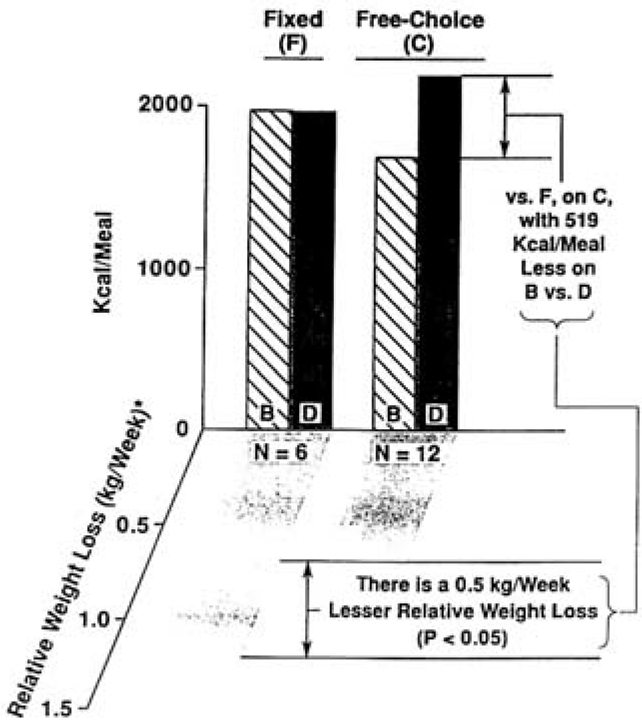


**FIGURE 19-7**

Appetite (choice and amount of food) modifies effect of meal timing on body weight. The lesser body weight loss on breakfast (B) versus dinner (D) observed on a free-choice versus a fixed 2,000 kcal meal occurred while calorie consumption on the free-choice meal was less (not more) than 2,000 kcal per meal. *, weight change on B subtracted from that on D.

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## RECOMMENDATIONS

### Analysis of Available Data

Current data suggest that a major meal should be eaten upon conclusion of a daily tour of duty; that is, if the duty starts in the morning, the major meal should be in the evening, or vice versa. In other words, scheduling should be by activity time rather than clock hour. This concept should be explained in an appropriate communication to commanding officers, so that it is reinforced by them and they are able to set a good example, which benefits themselves and their troops. In the interim, the wealth of data accumulated in the Minnesota-Natick studies and additional data to be obtained should be used to assess the relationship between performance and body weight change. This

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effort would benefit from further experimental studies in the laboratory and in the field. Such retrospective analyses are recommended, and the sooner the better. Endocrine and performance data are available in Minnesota from meal-timing studies that have thus far been the subject only of a technical report (Graeber et al., 1978). Data collected, for example by L. A. Stephenson and M. A. Kolka at NRDEC on the adrenal cycle (Personal communication, 1993), would benefit from a chronobiologic assessment that can provide an individualized assessment of statistical significance.

### Prospective Studies on Optimization of Dietary Supplements

Autopsies on very young American soldiers killed in battle during the Korean War revealed some vascular changes and suggested the need for prophylaxis by that age if not earlier (for review, see Halberg et al., 1986a). The methods of chronobiology allow level of risk to be detected by means of chronophysiologic monitoring (instead of relying on time-specified spot checks, biopsies, and autopsies) (Cornélissen et al., 1993; Halberg et al., 1993). Differences in dynamic features of blood pressure variation are found between the offspring of parents with and without high blood pressure and/or other cardiovascular disease (Halberg et al., 1990). Such differences as a function of family history of cardiovascular diseases are found early in life: shortly after birth and in adolescents. An unduly amplified circadian rhythm of blood pressure can be interpreted as presenting a heightened risk for vascular disease, notably stroke and nephropathy (Otsuka, 1994). Thus arises the opportunity for the Army to identify a portion of the population at risk and develop procedures for preventing a further deterioration of the vascular system and preferably for reversing changes that are already in place.

Dietary modification, such as the use of supplements, is one approach toward this goal. Much chronobiologic evidence from cooperative studies reveals the need to time the administration of dietary supplements according to rhythms. It has, for instance, become apparent that the effects of aspirin may be circadian stage-dependent, notably some prophylactic effects that may be related to the antiplatelet activity of aspirin (Cornélissen et al., 1991; Prikryl et al., 1991, 1993). Host tolerance of aspirin is also time-dependent (Siegelova et al., 1993). The best compromise between efficacy and tolerance must therefore be sought for prophylactic uses of aspirin. The same considerations apply to carnitine preparations that have a circadian stage-dependent effect upon blood pressure and heart rate (Cornélissen et al., 1994; Portela et al., 1993). Documenting this putative time-dependence on an appropriate scale and implementing the study of other dietary supplements given to recruits at the beginning of the tour of duty may be within the scope of Army nutrition.

Such a study would gain from including an echocardiogram and a 7-d ambulatory blood pressure and heart rate profile at the outset, with the

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measurements repeated 1 year later. The risk indices reflected by the pattern of blood pressure variation could thus be correlated with left ventricular mass and other indices of the heart morphology obtained by echocardiography (Cornélissen et al., 1994; Kumagai et al., 1992). If, in addition, the recruits can be persuaded to keep a precise diary of when and what they eat, it might be possible to study associations between any alteration of the cardiovascular chronomes and patterns in the relative consumptions of carbohydrate, fat, protein, and/or dietary supplements. Further guidelines may thus be derived for making recommendations of what to eat when. Given the age of recruits, this may be the best opportunity to carry out such nutritional studies with an aim toward prevention and self-help according to a chronobiologic approach now being advocated by the American Association for the Advancement of Science in a newly released report (Cornélissen, 1994; Culotta, 1993).

## AUTHORS' NOTE

As an aside, the first author was most happy during the post-World War II years in Austria to receive U.S. Army rations in the form of CARE packages. These were—and in the authors' opinion still are—invaluable, the difference in circumstances notwithstanding.

If it is impossible a priori to know how much food will be consumed by military personnel, and if a complete consumption of the ration cannot be realized, it seems reasonable that rations could be packaged so that unused portions can be saved and consumed at a later time or recycled for human and/or other use rather than discarded as waste. This would be a step beyond the technology that makes possible shelf-stable meals that do not require refrigeration before opening, but also a step far beyond our competence.

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# 20

# Social Facilitation and Inhibition of Eating

*John M. de Castro*[1]

## INTRODUCTION

The human is a social animal whose behavior is profoundly affected by social influences. "Of all the stimulation that impinges on the organism in its lifetime, stimulation from social sources is most important" (Zajonc, 1980, p. 50). Most human behavior is shaped or controlled by social forces. In fact, the act of soldiering itself is primarily a social phenomenon.

The social context can determine which behaviors are emitted. An individual may exhibit quite different behaviors in public than in private. For that matter, an individual's public behavior may vary considerably in different social contexts. A soldier may be quiet and reflective when alone; boisterous, outgoing, and rebellious with buddies; or obedient and retiring in the presence of a superior officer. In addition, these responses may be very different depending on whether a soldier is in the barracks on the base, at a private party off the base, in a church at home, or engaged in a firefight.

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Not only which behaviors are emitted but also their magnitude is largely determined by the social context. In general, the presence of other people tends to increase the expression of simple behaviors, such as well-learned motor responses, and it tends to interfere with complex behaviors, such as learning new material or responses (Zajonc, 1980). This effect of social context on the magnitude of behavior is generally referred to as social facilitation or inhibition. Social facilitation of behavior has been defined as "increments in the frequency or intensity of responses already learnt by the individual, shown in the presence of others usually engaged in the same behavior" (Crawford, 1939, p. 432).

In order for social effects to occur, the other individuals must in some way be involved with the subject. This involvement could simply mean that the other individual provides an audience, or the other individual could be a co-actor, actively engaged in a behavior along with the subject. Alternatively, the other individual may be behaving while the subject is the audience. This may evoke modeling or imitation by the subject, or it could provide vicarious learning. The mere presence of another is not enough. If the other person is blindfolded and the subject knows there will be no interaction, then social facilitation does not occur (Cottrell et al., 1968).

## SOCIAL FACILITATION OF FOOD INTAKE

Simple behaviors tend to be increased in magnitude by social influences. Because eating is a very simple behavior, it would be expected that more would be eaten when dining occurs with others present. Such an effect has long been known to occur with animals, who eat more in the presence of other animals than when they eat alone. Bayer (1929) demonstrated this phenomenon when he allowed a chicken to completely satiate by eating as much wheat as it wanted. he then introduced a hungry chicken who began to eat. The first chicken, although just satiated, immediately began to eat again. The same phenomenon has been replicated in pigs (Hsia and Wood-Gush, 1984).

The general phenomenon of social facilitation of eating has subsequently been demonstrated in a large variety of species, including chickens (Rajecki et al., 1975; Tolman and Wilson, 1965), fish (Welty, 1934), rats (Harlow, 1932; Hoyenga and Aeschleman, 1969), gerbils (Forkman, 1991), puppies (James, 1960), and primates (Harlow and Yudin, 1933). As an example, the results of the Harlow (1932) study with rats are summarized in Figure 20-1. Harlow fed rats either in pairs or alone on alternate days. As shown in Figure 20-1, the animals always ate more in pairs than when alone.

Even though the animal research clearly demonstrated that social facilitation was a robust phenomenon, it was still believed that somehow people were different. Indeed Harlow (1932, p. 12) wrote "…in the presence of individuals like ourselves…eating is influenced, probably not so much as

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to quantity as to appreciation. A good meal tastes better if we eat it in company of friends." Food intake by humans was looked upon as fundamentally the different from animals, that is, animals feed and humans dine! Researchers believed that "in man, the time of meals, as well as the choice of foods, their presentation, the cooking style, and the quantities presented…escape the direct control exerted in animals" (Bellisle, 1979, p. 164). As a result, the lively research on social facilitation of food intake in animals was not paralleled by similar research in humans.

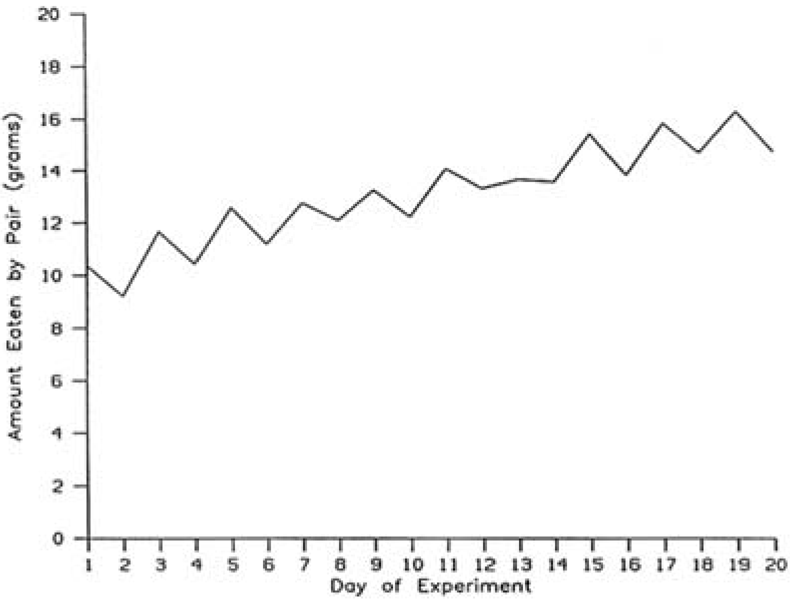


**FIGURE 20-1**

Mean daily intake (g) by pairs of rats fed on alternating days either together (odd-numbered days) or alone (even-numbered days). SOURCE: Adapted from Harlow (1932).

## Laboratory Studies of Social Facilitation of Eating in Humans

In spite of this thinking, laboratory findings have emerged which suggest that social facilitation also affects the eating behavior of humans. Frank (1944) demonstrated that subjects would eat simply in response to an instruction to eat, even when told that they were participating in an experiment on persuasion and that it did not matter whether they ate or not. Much like Bayer's chickens, humans, when paired with someone who eats a large amount of food, markedly increase their intake. Nisbett and Storms (1972) invited subjects to eat crackers in a taste test. Subjects tasted the crackers alone or paired with a

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confederate (model) who ate either 1 or 20 crackers. Normal-weight subjects ate 29 percent less with the low-intake model and 25 percent more with the high-intake model than when alone. Using a similar modeling technique, Conger et al. (1980) found an even larger effect: subjects exposed to a high-intake model ate 86 percent more crackers than those exposed to a low-intake model. In addition they demonstrated a comparable inhibitory effect. Subjects paired with someone who ate no crackers decreased their intake by 42 percent.

Polivy et al. (1979) described a similar modeling effect. Subjects who had fasted for 5 hours were asked to fill themselves with sandwich quarters in preparation for a "taste test." When the subjects were paired with a confederate who ingested eight sandwich quarters, they ate 57 percent more than when the confederate only ate two quarters. The influence of the model persisted into the taste test, with the result that subjects exposed to the high-intake model ate 31 percent more nuts than those exposed to the low-intake model. Using a similar modeling technique, Goldman et al. (1991) demonstrated 50 percent greater intake with a high-intake model than with a low-intake model in subjects who were deprived of food for 24 hours. Hence, in the laboratory, the food intake of a subject can be profoundly influenced by the food intake of a companion even when the subject is extremely hungry.

The snack intake of a subject appears to be affected not only by the intake but also by the nature of the companion. De Luca and Spigelman (1979) had a nonobese or obese model always eat the same amount of candy while filling out a questionnaire. Obese subjects tended to eat more candy when paired with the obese model than when with the nonobese model, and nonobese subjects were unaffected by the model's weight. Furthermore gender also appears to influence a subject's response to eating with a companion. During a "get-acquainted" session in the lab, female subjects ate 75 percent less when accompanied by a desirable male than when accompanied by an undesirable companion (Mori et al., 1987). A comparable effect was not apparent for males. Hence, in the laboratory, the snack intake of a subject can be greatly affected by the nature of a companion.

The amount people eat has been observed to be affected by the mere presence of other people eating with them. In the laboratory, subjects, regardless of gender, ate 94 percent more ice cream in groups than when eating alone (Berry et al., 1985). In more naturalistic settings, subjects' food consumption has also been observed to be affected by the presence of other people. Edelman et al. (1986) compared the amount eaten by subjects in a cafeteria to that ingested in isolated conditions. They found that both obese and nonobese people ate 48 percent more in the cafeteria than when alone. Krantz (1979) performed a naturalistic observation in a university cafeteria of the effect of eating with others on the intake of obese and nonobese subjects. Obese subjects purchased less food when accompanied by others than when alone. In contrast, nonobese subjects did the opposite; they purchased more food when accompanied by companions than when alone.

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## Social Facilitation of Spontaneous Eating in Free-Living Humans

The laboratory evidence makes a compelling case that social influences can produce strikingly large increases or decreases in the amounts of food ingested. However, this evidence is from studies of adjunctive intake, snacking, or, at best, a single lunch meal. This raises the question whether these results, mainly obtained under artificial conditions, can be generalized to the natural, everyday intake of normal people and whether similar results would be obtained over sustained periods of time.

### The Diet Diary Technique

For a number of years this author's laboratory has been using the diet diary technique to measure the spontaneous, natural intake of free-living normal adult humans (de Castro, 1987a, b; 1990; 1991a, b, c; 1993a, b; 1994; de Castro and Brewer, 1992; de Castro and de Castro, 1989; de Castro et al., 1986, 1990; Redd and de Castro, 1992). Seven-day diaries of food intake have been collected from adults, children, adolescents (de Castro and Goldstein, in press), and elderly humans (de Castro, 1993a) eating normally in their natural environment. Subjects record for each meal when it starts and ends, exactly what they eat or drink, their subjective states, and where they eat the meal. Most importantly from the standpoint of investigating social influences on food intake, they also record the number and nature of other people eating with them.

Self-report methods in general, and specifically the diet diary technique, have been believed to be inaccurate and unreliable. Indeed, the 24-h recall procedure for acquiring dietary information has been found to produce fairly inaccurate results (Brown et al., 1990; Dubois and Boivin, 1990; Krantzler et al., 1982; Larkin et al., 1991; Mullenbach et al., 1992; Myers et al., 1988). However, the diary self-report method has important differences in that subjects record every item they either eat or drink at the time it is consumed. This method minimizes the distortion of memory and improves the reporting of details and the estimation of quantities. It has been reported to be a reliable procedure with good agreement being found between separate records collected after a delay as long as 2 years (Adleson, 1960; Block, 1982; Heady, 1961; Livingstone et al., 1990; St. Jeor et al., 1983).

Evidence exists that subjects' self-reports of their intake are truthful reports of the foods they actually ingest. Surreptitious measurements of the actual amount of food consumed at meals have been found to be in close agreement with diary records (Eagles and Longman, 1963; Gersovitz et al., 1978; Krantzler et al., 1982). To check the validity of self-reports, this lab has each subject identify two individuals with whom they will be eating during the recording period. These individuals are later contacted and asked to recall or

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verify what the subject ate at the meals where they were present. After 1,015 verifications, in no case has the observer reported that the subject ate something that was not recorded in the diary or reported that the subject did not eat a recorded food.

Evidence also exists that the amounts of food reported in diaries underestimate actual intakes by about 20 percent (Bandini et al., 1990; Goran and Poehlman, 1992; Lissner et al., 1989; Livingstone et al., 1990, 1992; Mertz et al., 1991; Prentice et al., 1986). However, this is only a problem when the absolute amounts of nutrients ingested are required. In most research applications, the quantities ingested by one group or condition are related to those ingested by another group or condition. The error created by underestimation would be expected to affect all subjects equally and thus would not change relative values.

A number of sources of unsystematic error could affect diet diary records of intake. However, these sources of error would be expected to add to error variance and thereby tend to obscure relationships rather than produce systematic differences between intakes associated with different groups or conditions. "Random inaccuracy may lead to false negative conclusions…by reducing true associations but will not generate misleading correlations" (Livingstone et al., 1990, p. 708). That significant systematic and subtle relationships have been discerned in many prior projects (de Castro, 1987a, b; 1990; 1991a, b, c; 1992; 1993a, b; 1994; de Castro and Brewer, 1992; de Castro and de Castro, 1989; de Castro and Elmore, 1988; de Castro and Goldstein, in press; de Castro and Kreitzman, 1985; de Castro et al., 1986, 1990) in spite of the error attests to the robustness of the phenomena observed and indicates that the technique is sensitive enough for most research purposes.

### The Presence of other People at Meals

To investigate whether social facilitation influences people's intake outside of the laboratory, this author reanalyzed the diet diary data that were collected in prior studies (de Castro, 1987a, b; 1990; 1991a, b, c; 1993a, b; 1994; de Castro and Brewer, 1992; de Castro and de Castro, 1989; de Castro et al., 1986, 1990). The amounts ingested in meals eaten alone versus those eaten with other people present were reviewed. Results showed that the meals eaten with other people present were on the average 44 percent larger than the meals eaten alone (de Castro and de Castro, 1989) and included larger amounts of carbohydrate, fat, protein, and alcohol. In addition, this result was found to be an orderly phenomenon, the number of people present had a significant positive correlation with the amount eaten in the meal (Figure 20-2). This phenomenon, called a social correlation, indicates that the more people that are present at the meal, the more will be eaten (Figure 20-2, left panel). In addition, the correlation was equivalent even when meals eaten alone were

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excluded. Hence, not only are meals eaten with other people larger than meals eaten alone, but the greater the number of people present, the more that is ingested.

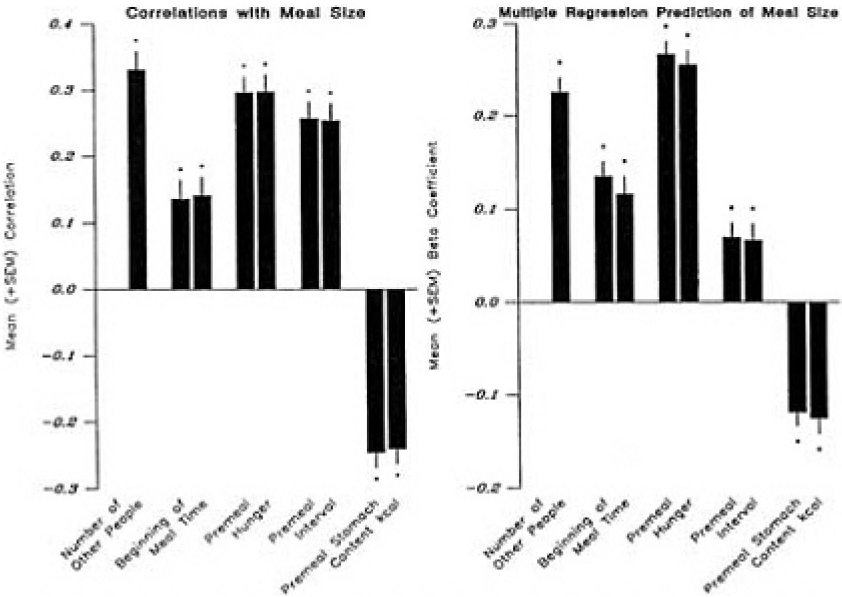


**FIGURE 20-2**
Mean ± SEM Z transformed correlation coefficients (left panel) and mean ± SEM ß coefficients (right panel) from the multiple linear regressions predicting the amount ingested in the meals on the basis of the number of other people present at the meal, the minute of the day that the meal was begun, the self-rating of hunger at the start of the meal, the time since the last meal, and the estimated contents of the stomach at the start of the meal.
The first bar of each pair represents the multiple regressions containing the number of people as a predictor, and the second bar represents the regressions without the number of people included. indicates that the mean is significantly ($P$ <0.05) different from zero as assessed with a $t$ test.

To investigate whether the influence of the presence of other people was primary or secondary to other salient influences on meal size, multiple linear regressions were performed that used the number of people present as a predictor of meal size along with four other predictors that are known to be related to the amount eaten at a meal: time of day (de Castro, 1987b), hunger self-ratings (de Castro and Elmore, 1988), premeal interval (de Castro and Kreitzman, 1985), and premeal estimated stomach content (de Castro et al., 1986). Results of these regressions were compared to similar regressions that did not use the number of people present as a predictor. The mean univariate correlations and the β (standardized regression) coefficients from these

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analyses are presented in Figure 20-2. The four-factor multiple regression without the number of people present accounted for 40.7 percent of the variance in meal size. When the number of people was added, the regression accounted for 52.4 percent of the variance. Taking into consideration social facilitation did not alter the influence of any of the other four factors. The β coefficients for these factors were the same regardless of whether or not the number of people was included. Hence, the presence of other people would appear to have a major effect on food intake, which is independent of other salient influences.

**Social Correlation as an Artifact**

It is possible that this relationship between the presence of other people and meal size is artifactual. The positive correlation could result from a covariation produced by a third factor, the time of day. Breakfast is the smallest meal of the day and may be eaten with the fewest other people present, while dinner is the largest meal and may have the greatest number of other people present. The social correlation may also occur as a result of alcohol intake, which may increase the caloric content of meals eaten with other people. Additionally, snacks are small and generally eaten alone, while meals are in general larger and more likely to be eaten with others. Another possible explanation for the correlations is that meals eaten in restaurants may be larger and eaten with more other people than meals eaten at home, which, in turn, may be larger and more social in nature than meals eaten elsewhere. Still another possibility is that meals eaten on weekends may be larger and eaten with more other people present than are meals eaten on weekdays.

This author investigated these potential artifactual explanations by isolating meals that occurred under specific conditions and demonstrated that, although the covariances exist, they do not account for the social correlation. Strong, positive, and significant correlations between meal size and the number of other people present—social correlations—were found separately for meals eaten during breakfast, lunch, or dinner; eaten in restaurants, at home, or elsewhere; accompanied by alcohol intake or without alcohol; eaten only as snacks or only as meals (de Castro et al., 1990); or eaten as meals during weekdays or during weekends (de Castro, 1991a). This finding suggests that the social correlation results from a true social facilitation of eating and is not an artifact of time, place, alcohol, or snacks. This facilitation is an important determinant of eating regardless of whether alcohol is ingested with the meal, whether the food is consumed as a snack or a meal, and when or where the food is eaten.

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## The Orderly Relationship of Social Facilitation to Intake

To look more systematically at this relationship, meals eaten alone or with one, two, three, four, five, six, or seven or more other people were separated, and average meal sizes were calculated (de Castro and Brewer, 1992). As seen in Figure 20-3, there is an orderly relationship between the number of people present and meal size. One other person present at the meal was associated with a 33 percent increase in meal size while 47 percent, 58 percent, 69 percent, 70 percent, 72 percent, and 96 percent increases were associated with two, three, four, five, six, and seven or more people, respectively. The size of the effect is remarkable. The magnitude of these differences is much larger than those obtained in prior research with physiological (de Castro, 1987a; de Castro and Elmore, 1988), age (de Castro, 1993b), circadian (de Castro, 1987a), seasonal (de Castro, 1991b), or psychological (de Castro and Elmore, 1988) variables, which suggests that the most salient factor associated with short-term food intake in humans is social facilitation.

The orderliness of the effect is also remarkable. It has been shown with many human behaviors that social facilitation can in general be adequately described by a power function (Latane, 1981). De Castro and Brewer (1992) found this to be true for social facilitation of meal size, which can be best

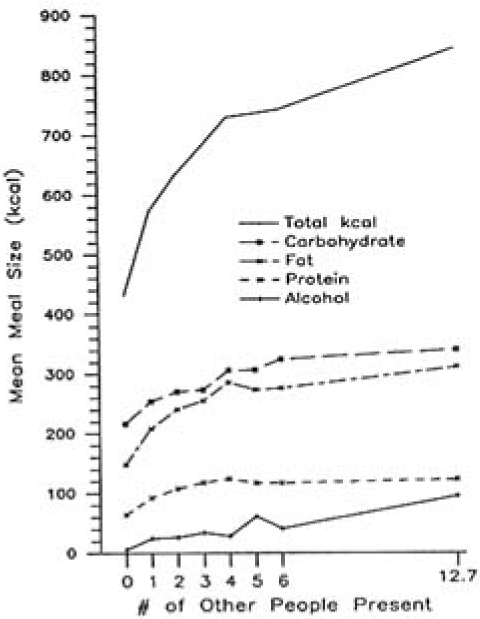


**FIGURE 20-3**
Mean meal size in total kcal (solid) or kcal attributable to carbohydrate (0), fat (*), protein (X), or alcohol (+) intake, as a function of the number of people present at the meal.

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represented by the power function, Meal Size = 485 N23, where *N* equals the total number of people present including the subject. Hence social facilitation of food intake is an orderly, lawful process that is similar to other social facilitation phenomena and likewise can be fairly well described by a power function.

## Social Facilitation and Increased Intake

Even with all this evidence, because of the observational nature of the research, it is not acceptable to conclude that the presence of other people is the cause of the increased intake. To establish causation, this laboratory actively manipulated the number of other people present by instructing subjects to eat only by themselves for a 5-d period, to eat normally for another 5-d period, and to eat only with other people for a third 5-d period. The order of these periods was randomized. In comparison to the normal instruction period, the subjects ingested on average 212 kcal, 11 percent, less per day when they were instructed to eat alone (Redd and de Castro, 1992). This result suggests that the presence of other people is indeed the cause of the increase in intake at meals.

In contrast to the "eat alone" instruction, when instructed to eat all meals socially, the subject did not eat significantly more overall or significantly larger meals than normal. This lack of an influence of increasing the number of people present at meals can be explained on the basis of the power function relationship between the number of people present and the amount ingested. There were on average 1.3 people present at the meals under the normal condition. In contrast, there were on average 1.7 people present at meals in the "eat socially" instruction condition. As is apparent from Figure 20-3, an increase from 1.3 to 1.7 people would not be expected to produce much of an increase in intake. This suggests that social facilitation may be of limited use in attempting to increase intake, unless the individual eats primarily alone or unless large numbers of other people can be added to the individual's eating context.

Note that the magnitude of the effect of eating alone, 11 percent, is considerably smaller than the magnitude of the social facilitation effects observed in unmanipulated contexts as reported above. In fact, the meal sizes reported during the manipulated alone condition were 20 percent larger than the alone meals during the normal condition (Redd and de Castro, 1992). This result might indicate that separating naturally occurring meals that just happen to be eaten alone from those that happen to be eaten with others may overestimate the impact of social facilitation of eating. Alternatively it might suggest that subjects compensate, increasing meal size in the alone condition to bring overall intake to more nearly normal levels. Research that looks at

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when people eat alone for periods longer than 5 days is needed to address this issue.

## THEORIES OF SOCIAL FACILITATION OF EATING

Research to date has demonstrated that social facilitation is a ubiquitous and salient influence on food intake that operates in the real everyday environments of normal people causing increased consumption of nutrients. Of all the myriad of stimuli that affect the ad libitum food intake of humans, social facilitation is the most powerful yet to be discovered (de Castro and de Castro, 1989). The question remains as to how the presence of other people may operate on the individual to influence the amount eaten in a meal. There are a number of theoretical explanations.

Social facilitation of eating may increase intake by producing imitation (Tolman, 1968) or by calling an individual's attention to food by observing a companion's activities. This hypothesis suggests that an individual alters intake in the direction of a companion's intake, eating more with a high-intake companion and less with a low-intake companion. Indeed, subjects in the presence of a high-intake model tend to eat large amounts and in the presence of a low-intake model eat very little (Conger et al., 1980; Nisbett and Storms, 1972; Polivy et al., 1979) even after a 24-h food deprivation (Goldman et al., 1991). However, this hypothesis would predict that women should eat more in the presence of relatively high-intake males and men should eat less in the presence of relatively low-intake females. Using the data obtained with the diet diary technique this author demonstrated that females eat more with males than with females as predicted by the hypothesis. However, contrary to the predictions of the hypothesis, males exhibited social facilitation, increasing intake, regardless of whether they ate with males or females (de Castro, 1994). Hence, this hypothesis cannot explain social facilitation at least in males.

The presence of other people might induce an aroused state that leads to greater consumption (Zajonc, 1965, 1980). This explanation postulates that the presence of other people increases the individual's drive level, which facilitates the emission of dominant responses. Eating in this enhanced drive state would be expected to result in an increase in the rate at which the individual emits the dominant response of ingesting food. Indeed, a pecking companion increases the peck rate of a chick (Tolman, 1964). Analyses of the diet diary data fail to support this hypothesis. If the presence of other people increased arousal level, then it would be expected that the energization of eating behavior would result in a faster rate of ingestion. In fact, no differences have been found between the rate of intake for meals eaten alone and those eaten with other people present (de Castro, 1990). Results for the analyses of the duration and rate of intake with differing numbers of people present are presented in Figure 20-4. As shown, the rate of intake does not increase with

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social meals and may in fact decrease with large groups (de Castro and Brewer, 1992). Hence, an aroused state hypothesis cannot explain social facilitation of intake.

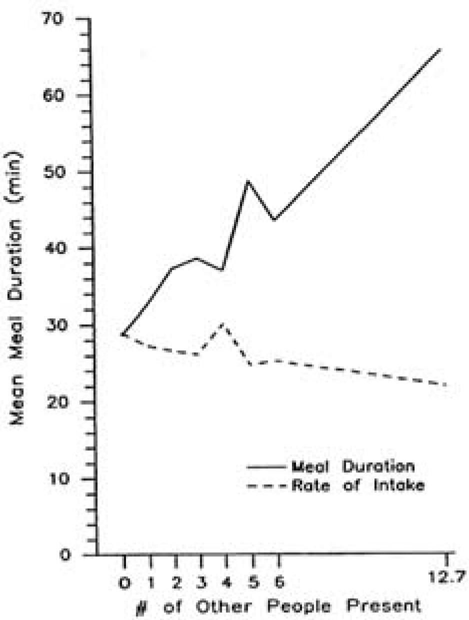


**FIGURE 20-4**
Mean meal duration (solid line) in minutes and the rate of intake (dashed line) in kcal/min, as a function of the number of people present at the meal.

Social facilitation might operate by inducing an emotional response, such as increased anxiety or elation, which may produce an increase in intake (Harlow, 1932; Harlow and Yudin, 1933). This hypothesis would predict an increase in self-reported anxiety or elation with meals eaten socially. Indeed, Harlow (1932) observed greater emotionality in rats fed with others than when fed alone. However, this hypothesis, like the increased arousal hypothesis, predicts an increase in the rate of intake. Also, this hypothesis predicts that when eating with a companion, the more emotionally arousing the companion, the more will be eaten. Hence, eating with people well known to the subject and with whom the subject is comfortable, such as family and friends, should produce the least effect on intake. Analyses of the diet diary data again fail to support this hypothesis. Meals were separated according to the type of companion present with the subject: friend, family, spouse, work associate, or other. Average meal sizes for meals eaten with and without each of these companion types and meals eaten alone are presented in Figure 20-5. As shown, contrary to the hypothesis, family and friends had the greatest impact

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on eating (de Castro, 1993a). In addition, the increased emotionality explanation predicts that when social facilitation occurs it should be accompanied by increased elation and/or anxiety, and when social facilitation does not occur, there should be no change in elation or anxiety. In fact, the self-ratings obtained for meals eaten with spouse, family, or friends, where social facilitation occurred, indicated less or equivalent anxiety. In addition, meals eaten with coworkers and others, where no social facilitation was apparent were eaten with higher levels of elation and anxiety (de Castro, 1993a). Hence, an increased emotionality hypothesis cannot explain social facilitation of intake.

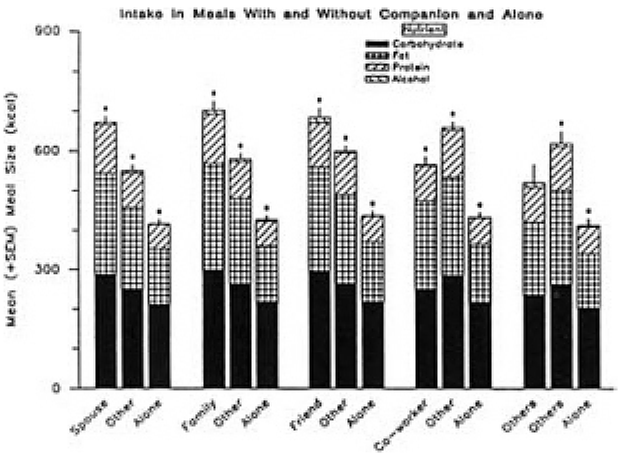


**FIGURE 20-5**

Mean (± SEM) amounts (kcal) ingested per meal of carbohydrate (solid portion of each bar), fat (cross-hatched portion), protein (hatched upward) and alcohol (hatched downward) for meals eaten with a particular companion type (first bar of each set of three), with others but not that companion type present (second bar of each set of three), and alone (third bar). The above the bar indicates a significant difference ($P < 0.05$) between the total meal sizes as assessed with a *t* test. The above the first bar signifies the "with companion-with other" comparison, above the second bar signifies the "with other-alone" comparison, and above the third bar signifies the "with companion-alone" comparison.

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Another potential explanation for social facilitation is that the presence of other people may increase perceived hunger (Tolman, 1968). A completely sated chick has been observed to begin eating again when placed in the presence of a hungry chick in the process of eating (Bayer, 1929). This hypothesis predicts that self-rated hunger would be higher at the beginning of socially facilitated meals but should be about the same at the end. In fact, in

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all cases of social facilitation, people eat to a significantly higher level of satiety at the end of the meal than when alone (de Castro, 1993a). In addition, when meals are eaten with friends, where marked social facilitation occurred, the levels of premeal hunger are equivalent to the levels observed when the subject eats alone (de Castro, 1993a). Hence, an increased hunger hypothesis also cannot explain social facilitation of intake.

Social facilitation might operate by producing disinhibition; the presence of a companion relaxes the individual, thereby releasing behavior from inhibition (Rajecki et al., 1975). Observing someone else eating may remove constraints on eating that otherwise would limit the amount ingested. Social factors might also act by distracting the individual from the eating process and thereby release cognitive restraints. This notion would predict a greater level of calmness during social meals and a release of restraints on eating. The results of the analyses of the diet diary data tend to support this hypothesis, which predicts that the better known the companion, the greater the relaxation and thus the greater the facilitation of intake. Indeed, this author found that social facilitation was greatest when the subjects self reported greater calmness. This calmness occurred when subjects ate with friends, family, or a spouse. In contrast, when subjects self-reported greater anxiety and less calmness while eating with work associates, classmates, or other companions, social facilitation had the least impact on intake (de Castro, 1994; see Figure 20-5). Hence, the disinhibition hypothesis is a viable explanation of social facilitation of eating.

Finally, the presence of other people might quite simple extend the amount of time spent at a meal and thus increase the amount eaten (de Castro, 1990). Verbal interactions that occur during social meals may simply cause a person to linger over the meal and as a result eat more. This notion predicts that the rate of intake should be the same regardless of the social conditions, but the duration of the meal would be extended when other people are present. Indeed, the diet diary data indicate that the duration and not the rate of intake increases when meals are eaten socially (de Castro, 1990; de Castro and Brewer, 1992; see Figure 20-4). Furthermore, this hypothesis is also supported by diet diary findings in which social facilitation only occurs when eating with friends, family, or a spouse (de Castro, 1994). Hence, the time extension hypothesis is also a viable explanation of social facilitation of food intake.

Although the theories are highly speculative, it is possible that both disinhibition and time extension occur and account for social facilitation of intake. Time is extended, regardless of companion type, resulting in increased intake with all companions. Examination of the diet diary data with multiple regression suggests that even when the number of people present is considered, the presence of spouse, family, and friends continue to be associated with higher intake (de Castro, 1994). With spouse, family, and friends, the subject should feel the most comfortable. According to the disinhibition model, these people would tend to have a relaxing effect on the subject and thereby increase

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intake by releasing inhibitions. The fact that where anxiety levels are the highest —during meals with coworkers and other companions—social facilitation is the smallest tends to support such an interpretation (de Castro, 1994). Hence, the best current available explanation for social facilitation involves a general time extension working in conjunction with a companion-specific disinhibition.

## CONCLUSIONS AND RECOMMENDATIONS

Social facilitation of food intake has a number of practical consequences. It may be useful for decreasing intake when it is too high. Because eating alone reduces intake by over 200 kcal/d (Redd and de Castro, 1992), it may be useful as a dietary strategy in weight-loss programs. In theory, all other things being equal, this 10 percent reduction in intake should lead to the loss of 1 lb (0.5 kg) of fat every 18 days, and, if maintained, a 20-lb (9.1-kg) loss at the end of a year. However, either behavioral or physiological compensation for the lowered intake may occur over time, reducing the effectiveness of the eating alone manipulation. Longer-term studies than those present in the literature are needed to assess the usefulness of this manipulation as a dietary strategy.

Social facilitation of intake may also be useful for increasing intake when it is too low. Soldiers in the field under-ingest nutrients, and social facilitation may be useful in promoting greater food intake. Three different strategies are suggested by the research: eating in groups, modeling, and orders. Whether or not any of these strategies would work is speculative, and they have not, to the author's knowledge, been tried for prolonged periods of time or under anything like field conditions.

The research suggests that eating in groups has a major impact on intake, but its effectiveness for soldiers in the field depends on the situation and conditions. If soldiers are in a situation where they mainly eat alone, then social facilitation is likely to be of more benefit than if they already eat socially. This notion is suggested by the power function, which indicates that maximum increase in intake is obtained when going from eating alone to eating with one other person. Less and less benefit is obtained as more and more people are added to the eating context. Eating in groups may still be of benefit, but the magnitude of the effect would be expected to be greatly reduced.

The research also suggests that eating in groups would only be of benefit when the soldiers have time available to extend the duration of meals. If eating time must be short due to the field situation, then social facilitation would probably not have much effect. In addition, the research suggests that social interaction and conversation may be necessary, and conditions in the field may not be conducive to these kinds of interactions. The research also indicates that

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eating with strangers would be ineffective. In sum, eating in groups may facilitate food intake if the meals are not already eaten socially, if time is available, if conversation is possible, and if friends are involved. However, once again, there are no studies of the long-term effectiveness of eating in groups. Behavioral or physiological compensation for the increased intake over time is a distinct possibility. Longer-term studies need to be carried out.

The research regarding modeling is not as well developed as that for eating in groups, and it has much larger gaps. Therefore, proposing field application is extremely speculative. In application, soldiers could be designated as high-intake models and instructed to eat large amounts in the presence of low-intake soldiers. Alternatively, soldiers who normally eat a lot could simply be paired with those identified as under-ingesters. Research to date has been confined to laboratory settings and has involved only single meals or snack intake. Whether similar methods would be effective in increasing overall intake for even brief periods in naturalistic settings is unknown. The only naturalistic data comes from diet diary studies which indicate that when females eat with a higher intake, male partner, an increment in food intake occurs. Again, the research is simply too sparse and lacks investigations of the long-term effectiveness of modeling as a facilitator of intake to reach any firm conclusions. Such studies need to be performed.

A final alternative is simply to order the soldiers to eat more. This method might be effective if a "facilitator" was designated whose job it was to order the soldiers to eat at mealtime and to prompt soldiers to eat more when they stop eating. The research on compliance suggests that this technique could be effective, however, such a scheme could have such negative consequences as producing anger and resentment, and the research on long-range effectiveness is absent.

In summary, the research on social facilitation and inhibition of intake clearly demonstrates that social factors can profoundly affect the amount of food ingested on a short-term basis. Eating in groups, modeling, and ordering all result in large increases in intake. There are no data to suggest that these strategies would not be effective in the field with appropriate conditions and implementation. However, there is also no direct evidence that such strategies would be effective, particularly over an extended period of time. Due to the magnitude of the effects, these strategies should be viewed as promising, and further research performed to ascertain whether this positive effects can be realized.

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## DISCUSSION

MARY MAYS: When we first heard about John de Castro's studies, we decided to see if we could get the effect in the lab Herb Meiselman and I agree that it is nice to get both field-based and lab-based studies agreeing, and this has never really been done in a systematic way.

So, we fed people—either alone or in groups of four—a spaghetti, salad, and dessert dinner. They were all the same sex. When we began, we put people in groups where they did not know one another because we did not want interference. We got no effects at all, no enhancement.

Then when we decided to test friends in both male and female groups, we got a 50 percent increase in both genders.

However—and this is something we did not make a lot of—it all practically increased dessert consumption. I know you did not find any differences in the nutrient composition, but practically all the social effects were increased consumption of dessert.

JOHN DE CASTRO: These are interesting findings, and they fit well with the comparison type finding I have reported. However, social facilitation may be affecting different components of the meal in different contexts.

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# 21

# Lessons from Eating Disorders

*John P. Foreyt,*[1] *G. Ken Goodrick, and Jean E. Nelson*

## INTRODUCTION

Anorexia nervosa, bulimia nervosa, and binge eating disorder are referred to as *eating disorders* because the most observable symptoms involve pathological behaviors, including binging, purging, and self-starvation. These disorders have seen a dramatic increase in prevalence over the last 25 years in the United States (Strober, 1986). The disorders usually begin in early to late adolescence and are most commonly found in females, although their prevalence in males is not as rare as was once believed. Today, approximately 5 to 10 percent of all eating-disordered patients are male (American Psychiatric Association, 1987). Characteristics of the disorders are the same for both sexes, and there does not appear to be a gender difference in the effects of treatment (Szmukler and Russell, 1986).

Evidence suggests that eating disorders are influenced by physiological factors, familial food habits, sociocultural influences, self-perception, familial interaction patterns, and emotional status (Bemis, 1978; Blundell and Hill,

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1990; Brewerton et al., 1989; Bruch, 1973, 1977; Garner et al., 1982; Halmi et al., 1991; Pike and Rodin, 1991; Rosman et al., 1977; Strober, 1981; White and Boskind-White, 1981). Eating disorders may develop as the result of developmental processes that cause the individual to place an undue importance on physical appearance as a way to obtain love and to feel in control (Bruch, 1978). This emphasis on appearance is part of modern Western culture, and it is often reinforced by parents. The need to obtain love may be exaggerated by a rigid or nondemonstrative family of origin. The need for control may be exaggerated by the emphasis on control in a rigid family or by the inability to control other aspects of life (Bruch, 1973).

The resulting focus on appearance leads to a fear of becoming fat. Along with this fear a distorted body image may develop, so that people with eating disorders perceive themselves to be fatter than they really are (Crisp and Kalucy, 1974; Warah, 1989). The fear of fat and body image distortion usually lead to dieting, which may lead to binging. Binging may lead to obesity with binging (binge eating disorder) or to a more normal weight with binging and purging (bulimia nervosa). Some dieters may be able to achieve a state of self-starvation, either with or without some binging (anorexia nervosa).

Thus, while objective criteria for diagnosis remain observable eating and purging behaviors, the dynamics of the disorders involve self-esteem and body image. To complicate matters, the pathological behaviors may alter physiological functions, which in turn may affect emotional and cognitive functioning (Garfinkel and Garner, 1982; Mitchell et al., 1991). Therefore, both the diagnostic criteria and the dynamics of the eating disorder should be taken into account simultaneously so that the behavioral, cognitive, affective, and social manifestations of the disorder can be put into a conceptual whole.

The eating disorder that will be emphasized here is anorexia nervosa, since the dynamics of anorexia nervosa most closely resemble the reduced energy intake manifested by military troops in field operations. The symptoms of anorexia nervosa may be experienced by "normal" individuals but to a less serious degree and only for short periods of time. For example, most Americans have a fear of becoming fat or fatter and have a desire to feel in control of their eating. Most women and many men wish they were thinner. To the extent that normal troops have some of the same dynamics, a study of anorexia nervosa may provide lessons for preventing self-inflicted undernutrition in field situations.

## ASPECTS OF EATING DISORDERS

Eating disorders vary in the criteria required for diagnosis; however, there are several common psychological themes. These include:

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- extreme fear or disgust of being fat;
- low self-esteem, exacerbated by a hypercritical body image, and failure to control eating habits and weight;
- the belief that self-worth hinges on bodily appearance;
- perceived blocks to developing interpersonal relationships due to negative self-image—the feeling of isolation associated with eating disorders; and
- the intrapunitive nature of exercise and other abusive purging techniques—the feeling that self-punishment is deserved for failure to control eating or weight (Garfinkel and Kaplan, 1986).

Because anorexia, bulimia, and binge eating disorder all have overlapping symptoms and often occur in the same people (about half of all anorectics also have bulimia, and approximately 40 percent of bulimic patients have a history of anorexia [Eckert, 1985; Mitchell and Pyle, 1985]), the various causes of the disorders are also shared.

## Familial Factors

Eating disorders are the products of multiple influences. One of the most important of them is the family, for it affects the individual's development of self-concept, values, food and eating patterns, and personal standards. Several studies involving first-degree relatives of anorectic women have suggested that eating disorders run in families. Specific ways in which the family may affect eating disorders have been suggested by various clinicians and theorists (e.g., Bruch, 1973, 1977; Pike and Rodin, 1991; Rosman et al., 1977; White and Boskind-White, 1981).

In many families, the presymptomatic anorexic child is frequently perceived as the "pride and joy" of the brood, often characterized by parents as being well behaved, achieving, and perfectionistic (Halmi et al., 1977). Some researchers (e.g., Bruch, 1978; Rosman et al., 1977), however, suggest that many of the anorectic traits are engendered by the particular interactional patterns and values of the families involved. Bruch (1977) noted that among families of anorectic patients, parents tended to be overprotective, overconcerned, and overambitious. Within this setting, she noted that obedience and superior performance of the children were a concomitant expectation.

## Biological Factors

Abnormalities in the production and regulation of the hormones and neurotransmitters in the brain that control appetite and food intake have been the subject of much research in recent years. Some studies have found low

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concentrations of the metabolites of serotonin and norepinephrine in subjects with anorexia and low concentrations of serotonin in subjects with bulimia (Blundell and Hill, 1990; Brewerton et al., 1989). These neurotransmitter disturbances are similar to those found in clinically depressed subjects, and, indeed, antidepressant drugs that alter the effects of serotonin and nor epinephrine seem to decrease the frequency of binging in bulimic patients (Hughes et al., 1984; Pope et al., 1983; Stewart et al., 1984). It is estimated that women diagnosed with major depression have twice the average lifetime rate of bulimia and eight times the average rate of anorexia; from 40 to 80 percent of anorectic patients have been or are seriously depressed (Eckert, 1985).

## Behavior, Mood, and Personality Factors

Behaviors are the external manifestation of the eating disorder; their nature and frequency largely define the severity of the problem. Examples of these behaviors include binge eating, vomiting, limited food intake, excessive exercise, and strange food-related rituals (e.g., order of food consumption, insistence on a specific place setting, lists of "forbidden foods," and regular departures to the bathroom after meals).

Strober (1981) studied the etiology of bulimia in anorexia nervosa and found significant behavioral differences between bulimic and nonbulimic patients. Primarily, his results indicated that the family life of the bulimic anorexic is more tumultuous, conflict ridden, and negative in comparison to that of the nonbulimic. Bulimics also seem to have greater tendencies to impulsive behaviors: drug use, alcoholism, stealing, and self-mutilation (Casper et al., 1980; Garfinkel et al., 1980; Wilson, 1991). In contrast to the typical view of the anorectic as introverted, the bulimic variation is likely to be more socially and sexually active (Casper et al., 1980; Johnson, 1982; Russell, 1979).

There appears to be a significant comorbidity of the affective and anxiety disorders with anorexia nervosa (Halmi et al., 1991). Although personality disorders, especially borderline personality disorder, have been though to be associated with bulimia nervosa, the relationship is not clear since personality trait scores may change so that such a diagnosis cannot be made after treatment for bulimia (Ames-Frankel et al., 1992). A recent study reported significantly higher rates of major depression, panic disorder, borderline personality disorder, and avoidant personality disorder among subjects with binge eating disorder (Yanovski et al., 1993).

A number of psychological traits characterize the anorectic, including shyness, anxiety, and obsessive-compulsive behaviors (Bemis, 1978). These characteristics, although the source of much inner turmoil, are frequently manifested in outward behaviors such as orderliness and high achievement, which are viewed positively by family and friends.

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## Cognitive Factors

Most, if not all, who suffer from an eating disorder have a structure of dysfunctional cognitions that exists in association with their aberrant eating behaviors. Body image in anorexia is one of the most powerful examples of how distorted cognitions can influence the cause and course of an eating disorder. The anorectic perceives his or her body as too large regardless of the degree of thinness achieved (Warah, 1989). Because this distortion does not diminish with weight loss, it persists as a relentless incentive. Bruch (1973) noted that this disorder is not "cured" until the body image misperception has been corrected, even if substantial weight gain has been achieved in therapy.

Examples of cognitive distortions have been reported for anorexia nervosa (Garner et al., 1982), binge eating (Loro and Orleans, 1981), and obesity (Mahoney and Mahoney, 1976). Certain of these distortions are present in all persons with eating disorders, indicating the possibility of a cultural pattern gone awry. In some people, for example, staunch perfectionism is the cause of much distress and sometimes failure. These individuals proceed with substantial success on a diet until the first infraction occurs, no matter how minor. The inability to maintain a perfect record sends many into a binge that ends with self-recrimination and guilt. Perfectionism in the anorexic takes on an even more extreme form. Some carry this trait in all aspects of their life as well as in their anorexia. As indicated earlier, people with anorexia are often characterized by their friends and family as the "perfect one."

## Social Factors

For many who have an eating disorder, social factors are associated both with the etiology and perpetuation of their problem (Garner et al, 1980). From a sociocultural perspective, eating disorders are likely to be a product of contemporary American society (i.e., a society that places inordinate value on slimness while simultaneously emphasizing the consumption of its abundant food supply). At the personal level, these societal traits are translated into interpersonal transactions that lead the susceptible into an eating disorder. For many young people, the most important social influence is the family, but other factors are important as well.

In some cases of bulimia, for example, the idea of purging is obtained from an acquaintance or friend as an action to avoid the consequences of excessive eating. For the susceptible, it begins as a logical and apparently socially acceptable way to "have your cake and eat it too." Unfortunately, this rather innocent beginning can progress into a disturbing, all-encompassing compulsion. For anorectics, it is not unusual to find that their social activities or work or both are associated with their disorder (Eckert, 1985).

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One of the phenomena frequently observed in individuals who suffer from an eating disorder is difficulty with interpersonal relationships (Mitchell and Pyle, 1985). Among bulimics, problems in this area are the frequent cause of a binge.

Eating disorders may also be triggered by traumatic separations and losses (Garner et al., 1980; Kalucy et al., 1977; Strober, 1981). These situations may include the breakup of a home, death of a family member or friend, going away to college or the military, or family illness.

## ANOREXIA NERVOSA

Anorexia nervosa is the eating disorder most noted for its severe course and consequences. It is the eating disorder that is more likely than the others to result in death, most often from complications arising from the state of starvation.

Anorexia nervosa is a perplexing condition, for its most notable characteristic is self-imposed starvation in a country and culture blessed with an abundance of food. However, for anorectics, the apparent illogic of their actions is overridden by a psychological framework ruled by two powerful contingencies: the reward of weight loss and a morbid fear of fatness (Garner et al., 1982). Even at very low weights that are beyond the point of social desirability, attractiveness, and good health, anorectics deny that they are too thin and instead insist that they are too fat.

Despite the literal meaning of the term *anorexia nervosa*, appetite loss of nervous origin, a diminished appetite is rare among people with this disorder (Bruch, 1986). Anorectics are often obsessed with food and may spend hours reading cookbooks, preparing meals, and serving food to others. They may develop rituals involving food, including cutting it into tiny pieces, hoarding it, weighing it, or hiding it and disposing of it at a later time.

The Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 1993) diagnostic criteria for anorexia nervosa are:

A. Refusal to maintain body weight at or above a minimally normal weight for age and height (e.g., weight loss leading to maintenance of body weight less than 85 percent of that expected; or failure to make expected weight gain during period of growth, leading to body weight less than 85 percent of that expected).
B. Intense fear of gaining weight or becoming fat, even though underweight.
C. Disturbance in the way in which one's body weight or shape is experienced; undue influence of body weight or shape on self-evaluation, or denial of the seriousness of the current low body weight.

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D. In post-menarcheal females, amenorrhea, i.e., the absence of at least three consecutive menstrual cycles. (A woman is considered to have amenorrhea if her periods occur only following hormone, e.g., estrogen, administration.)

In addition, the DSM-IV specifies two types of anorexia nervosa:

- Restricting type: During the episode of anorexia nervosa, the person does not regularly engage in binge eating or purging behavior (i.e., self-induced vomiting or the misuse of laxatives or diuretics).
- Binge Eating/Purging type: During the episode of anorexia nervosa, the person regularly engages in binge eating or purging behavior (i.e., self-induced vomiting or the misuse of laxatives or diuretics).

There is evidence for increased comorbidity of affective and anxiety disorders with anorexia nervosa. Moreover, alcoholism and other psychiatric diagnoses, including other eating disorders, are more likely in first-degree relatives of anorectics (Halmi et al., 1991). Anorectics of the binge-eating/purging type tend to be heavier, with more lability of mood, impulsivity, and drug abuse (Mitchell and Pyle, 1985). The anorexic patient in a state of starvation may suffer cardiovascular and respiratory changes, problems with renal function, electrolyte imbalance, edema, hematological changes, gastrointestinal complications, and neurological changes (Garfinkel and Garner, 1982). Additional symptomatology includes low metabolic rate, loss of bone, cold intolerance, insomnia, alopecia, swollen joints, and dry skin (Bemis, 1978; Williamson, 1990).

From 90 to 95 percent of anorectics are female (American Psychiatric Association, 1987). Such disproportionate representation of females indicates the strong cultural influences in the etiology of the disorder (Brownell, 1991). In the United States and many other Western nations, slenderness has become synonymous with attractiveness, and the achievement of both is an expectation more of women than of men. In Western cultures, males are more likely to be evaluated in terms of their actions, or what they do, whereas females tend to be judged in terms of their appearance, or how they look (Foreyt and McGavin, 1989).

Anorexia is often seen as a response to the demands and expectations of adulthood and independence. Compulsive fasting may bring a sense of order to the patient's life by allowing her to exert some control over herself and her body. Her ability to lose weight may give her a sense of pride and achievement, and her rigid self-imposed rules governing food may serve as a substitute for genuine independence. The denial of her own needs through fasting may be a way of expressing that she will not allow other's demands to be imposed on her.

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These dynamics of anorexia nervosa, involving self-imposed undereating as a way to establish feelings of self-control and independence and to reduce chaos, may be the most interesting to explore in their application to troops in the field.

## APPLICATION TO TROOP UNDERNUTRITION

The dynamics of anorexia can be compared to the field situation when one considers the parallels between the anorexic's family and the "family" structure in the military. The majority of soldiers can be thought of as older adolescents in terms of their developmental stage. The officers serve in loco parentis to provide leadership and protection. Like the anorexic family, the military, especially in stressful field operations or combat, operates under conditions conducive to rigid rules for relationships, overprotectiveness, and enmeshment and high cohesion in the sense of close teamwork and buddy support. There is also a strong prohibition against intertroop conflict or expression of anger.

Thus, the stage is set for the adolescent to develop a strong need for independence and autonomy; the natural way to cope with stress or combat is to try to make oneself into a self-sufficient individual. In this way the individual reduces feelings of vulnerability. At the same time, however, since a sense of mastery is not complete, there is a dependent turning toward authority to alleviate fear and confusion. This results in an inner, mostly subconscious, conflict between dependence and independence needs.

One overt outcome of this conflict is that the individual develops a defiant and oppositional attitude toward authority. This defiance coincides with bonding with peers to reduce feelings of individual vulnerability and to maximize social acceptance. Thus norms develop among the troops that whatever comes down from authorities must be viewed with distaste as a way of communicating brotherhood with peers and defiance of parental figures. Thus, individuals may rate rations as acceptable in laboratory test situations, but they may shun the food in field situations when they are in the presence of their peers.

Another related hypothesis is that when soldiers are in military field situations, there is very little they can do to control life. Most actions are the result of obeying commands with little sense of self-control. The act of not eating a recommended portion of rations may be a way of asserting personal control apart from the context of displaying to peers one's defiance of authority.

The young anorexic female may enter into self-starvation as a way to convince herself that she is in control and achieving a perfect body; she has a vision of herself that she is trying to attain. The self-vision for a young soldier, male or female, may be along the lines of a "lean and mean fighting machine." The soldier may see undereating as a sign of toughness, sacrifice,

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and machismo and eating full rations as a sign of self-indulgence. Being full of food may be perceived as preventing one from being on the fighting "edge." It is true that most people feel less alert after a full meal. Another aspect of control may involve in undereating to reduce the need for defecation, which may not be as easy or pleasant during field operations.

Other considerations regarding underconsumption of rations are that under stressful conditions such as combat, appetite is reduced (Popper et al., 1989). Fear decreases gastric secretion and blood flow and inhibits gastric motility. This reaction is related to the release of corticotropin-releasing-hormone, which is the principal organizer of the stress response, leading to behavioral arousal, sympathetic stimulation, and a decrease in appetite due to increased glycolysis and blood glucose concentration (Ur and Grossman, 1992). One aspect of stress to consider is that some individuals are thrill seekers who seem to enjoy the mental activation caused by the stress response. These individuals would also be more likely to enjoy the alert feeling caused by undereating. Undereating is acutely associated with reduced availability of serotonin and opioids in the paraventricular nucleus (Norton et al., 1993). Low serotonin and opioids may cause agitation and enhanced alertness. This heightened state of alertness may alleviate feelings of boredom in noncombat field operations.

## RECOMMENDATIONS

A discussion of the psychodynamics of self-imposed undernutrition displayed by troops in field operations in the light of eating disorders is speculative. To determine whether these dynamics are operative, research needs to focus on the attitudes and cognitions of troops. When this information is determined, then persuasive communications can be developed and tested to see if consumption of rations can be improved.

Recommendations for future research include the following:

- Hold focus groups with troops to engage them in conversation about eating in the field. These groups would be led by nonmilitary personnel who would attempt to elicit responses that were not affected by the demand characteristics of military life (i.e., the need to look good in order to stay out of trouble).
- Use anonymous questionnaires to ask the troops about the topics that arose in focus groups and about the attitudes and beliefs that were discussed in the previous section. These topics include: (1) attitudes towards authority; (2) attitudes and preferences about the rations; (3) respondents' perceptions of their peers' views about the rations; (4) reasons why respondents do not eat fully; (5) reasons respondents believe their peers have for not eating fully; (6) how respondents feel physically and mentally when undereating versus eating fully and their perceptions about how eating might affect combat readiness; (7)

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how respondents' appetites have been affected by boredom, stress, or anxiety in premilitary life and in field and nonfield military life; (8) respondents' beliefs about the ability of the rations to cause weight gain; (9) respondents' attitudes about peers who always eat everything they can; (10) respondents' attitudes about full eating and defecation in the field; and (11) respondents' tendency toward thrill seeking.

- An analysis of data from the focus groups and questionnaire would be the basis for developing persuasive communications designed to increase ration consumption. If the aspect of control-defiance appears operative, then communications would be designed to emphasize the self-nurturing aspect of full nutrition, rather than the subordinate-obedience aspect of complying with full eating orders.

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## DISCUSSION

JOHN DE CASTRO: John, a lot of the eating disorders, they are what I think of as the tip of the iceberg phenomena, those individuals come in seeking help or are referred to help.

The vast majority of people who are eating disordered are not showing up in those kinds of situations.

We studied with the food intake diaries for bulimics who said that they would work with us as long as we didn't make them go to therapy, they didn't want to have anything to do about that.

And what we found was that a lot of binge eating did, indeed, occur with other people. And a lot of bulimic behavior occurred socially.

It turned out that, the more people that were present at a binge, the more they would eat.

JOHN FOREYT: I saw your data and found it interesting. That is why I made that comment.

JOHN DE CASTRO: But if you are saying getting people together to control binging, with a lot of bulimics, it works the opposite way. The more people you bring in, the greater the binge is going to be.

JOHN FOREYT: Those are the people, again, who don't seek out help. We have seen it in college sororities, but that was because, you know, people study college sororities. But you get a population that we don't get, which are people seeking out help. That is very interesting. But yours may be more typical of military, people who do not seek out help in terms of eating patterns.

JOHN DE CASTRO: What we find in the university undergraduate female population, is that there is an incidence of about 10 to 12 percent. It is very high.

JOHN FOREYT: You are right, this would be the tip of the iceberg.

JOHANNA DWYER: Are there any studies that the military might know about, of the prevalence of these disorders in the military?

ALLISON YATES: I think there may be one at the military academy. I know that they monitor that kind of thing much more closely. Whether that has been anything other than a record keeping, I think they are doing some of that at West Point.

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BARBARA ROLLS: Are the cognitive treatments any different in the male population we see, the small percentage?

JOHN FOREYT: The male population has been essentially untreated. There are very few. Arthur Andersen has published some work on the treatment of male bulimic and male anorexics. Most of them have gender disturbance that come to treatment. So, you would focus on whether they are unhappy with their feelings about themselves.

But otherwise, the treatment is similar, but with that added.

PARTICIPANT: (Question off microphone re: perfection.)

JOHN FOREYT: Oh, the need to be perfect is definitely there. Sure. The ones I treat now, one is a model, an athlete—their life styles are in a life style that needs a very low body weight, in the first place, or a heavy emphasis on appearance. So, you need to deal cognitively with that. And they are tough, I mean, obviously, because that is how they make their living, or a big part of their life.

BARBARA ROLLS: And something you didn't really mention, but obviously I have worked with eating disorder patients a lot, but what may be a problem in the military is the excess exercise and activity. And that might be something that you don't see so much in the eating but people in the military are—

JOHN FOREYT: Good point, Barbara. There are many ways to compensate for calories. And I just mentioned one of them. But you are right, there are lots of ways including strong, heavy, emphasis on exercise. And I think you are right, and very well taken. That is very strong one.

DAVID SCHNAKENBERG: A question for Dr. Halberg. A few years ago the army undertook a couple of studies to cope with the problem of translocation of troops, say from the U.S. over to Europe, and jet lag, what could you do collectively.

And some studies looked at a package of things—sleep priority, lighting control, perhaps some timing of eating.

Subsequently, there were some minor effects shown at the outcome, but we couldn't tease out how much was diet, how much was light control or whatever.

Is there anything in the emerging literature that deals with that problem, in terms of rapid relocation of troops, both directions, east and west? I wonder if there is something fruitful that we could consider putting on our research agenda to try to adjust something with at least the diet side of coping with the circadian or other rhythms.

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FRANZ HALBERG: The question is, if you have chronome, with the new recognition, we rapidly adjust our circadian. Society simply synchronizes it. That is why I showed the 15¹C continuous darkness firing of neurons. Certainly, society synchronizes it, but it is there in vitro.

So, attention to circumvent things would be quite important because it could reverse the effect of circadians. And today we have the monetary capabilities. We could do one not only on temperature and activity monitors, very refined ones.

So, we would know whether that in terms of performance—as you suggest, it is a reasonable thing to do, and we could do it. And of course, these trips occur with some delays. We can optimize it, and we should optimize the chronome. People have unhooked the circadian, so, again, that is in the 1950s.

Today, we have also components that play a critical role. Most of these are soldiers going to combat, going to Bosnia, perhaps, or wherever. For those it would be very important to take the chronome into account and see what you can do to, first exercise concomitantly, and if you need to do it, then remember, that eating has been according to what is recommended.

But we should do pharmacodynamics and pharmacokinetics, before we recommend drugs.

So, yes, there is a problem. Yes, there is a chronome. We have ways to optimize things. The work remains to be done.

JOHANNA DWYER: I thought I heard you say it again. Now you said melatonin. Before you said carotene and aspirin, I thought you said, as well. Could you suggest—I could see if, in fact, these agents were to modify these rhythms, how that would work.

What I don't understand is how it would be possible, given the quixotic sorts of demands on soldiers, how you could do very much with circadian rhythms. I mean, if they have to fight, they have to fight. Could you explain that a little bit more?

FRANZ HALBERG. I would love to. I would like to kill two birds with one stone. One stone is for actually what Dr. Schnakenberg of a major concern about this would be concern about the commanders before you come to the soldiers.

So, when he came to the soldiers he could use the soldiers as models for the population as a whole, if cardiovascular changes, as we found in Korea, are suddenly there at 19 and 20 years of age.

At least we can measure the differences in blood pressure or in stroke, or in the acceleration of the velocity in the blood, if circadian attributes at birth in newborn, then the timing beyond is probably the best catch-all to have a prophylactic pill.

So, they are two separate problems but they mesh and we have a concern about the circadian circuits.

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If I could speak for just one more second. I want to make this point very strongly, that one of my fellows just finished a study where he gives an answer to a meta analysis of 70,000 people who all received aspirin, and the story is still controversial.

What he showed was that the effect on blood pressure at one time was in one direction, but the rest of the time it was in the opposite direction. And when he took everything together, there was no effect.

So, we can continue with this potential of 40 percent diagnosis. But in fact, what it does, it keeps on doing. So, the army would be a wonderful place to do this.

HOWARD SCHUTZ: This is for John. I am cheating because I talked to him at the break, but I want to share it. In addition to increasing the length of time because of number of people you interact with, I entertained the hypothesis, which he then agreed with and he will explain, that it could be also due, in part, to disinhibition.

The more people that are there, the more likely they will behave in a way that you don't typically behave, and give you a model. And then it breaks the conflict.

I think that alcohol data supports that, because I think it contributes to further disinhibition.

JOHN VANDERVEEN: I agree.

JOËL GRINKER: John, when I talked to you, you said that you have some evidence of compensation in subjects that you had data on over only one or two days. I wondered if you could speak to that. Did that only go on in specific meals or what?

JOHN DE CASTRO: When I was talking to you about that, I was referring to the manipulative study, where we told the students to eat by themselves.

The evidence for the compensation was simply the fact that the alone meals were much larger than what you see in spontaneously ingested alone meals.

There are a number of interpretations but one of those is the compensatory interpretation of that.

ROBERT NESHEIM: Thank you for the last four speakers and the issues they are dealing with. Now we want to start taking a look at some of the strategies that might be employed to combat undernutrition, and see about the resolution of the problem.

In order to kick this off, we have asked a panel of discussants to come together and to share some of their thoughts and to interact with themselves

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if they desire, and eventually let the whole group here comment on what they have heard over the last essentially day-and-a-half.

The members of the panel are Robert E. Smith, who is a senior vice president of Nabisco Research Foods Group in New Jersey; Howard Moskowitz of Moskowitz Jacobs, Inc. of Valhalla, New York; Cheryl Achterberg, Department of Nutrition at Penn State University, University Park; and Robin Kanarek, Department of Psychology at Tufts.

I don't know who is going to start. Bob, do you want to?

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# 22

# A Plan to Overcome Ration Underconsumption

*Edward Hirsch*[1]

## INTRODUCTION

The chapters in this book illustrate the complexity of the ration underconsumption problem and the broad range of variables that are potentially relevant to its solution. From the perspective of trying to integrate this information into a coherent plan, one is struck by the contrast between the range of variables that bear on this issue and the potential difficulty in transporting these findings and concepts to the military field feeding environment. For this reason any plan that addresses the issue of inadequate food intake in troops fed operational rations must include input from all the military agencies involved in field feeding policy, ration development, training, nutritional guidelines, and logistics. In addition, it is also important to seek advice from senior food service personnel and military commanders about whether variables that have been shown to enhance food intake in controlled settings can realistically be applied in a military field feeding context.

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## PROPOSED PLAN

The factors that affect troop ration consumption and acceptance can be broadly classified into two categories: those related to the rations and those directed toward modifying the field eating environment in some manner. Table 22-1 shows an arrangement of these variables in a manner that emphasizes this distinction. Note that most of the factors in the table represent a broad class of variables and possible manipulations. The table also indicates whether there is evidence of increased food consumption and improved customer satisfaction after treatments. The Yes-No entries in the second column are based on laboratory and field experiments or correlational data from the field. A "Yes" entry only indicates there is at least one positive outcome when the variable under consideration has been examined.

TABLE 22-1 Strategies for Improving Ration Consumption and Acceptance

| Proposed Manipulations | Has Positive Effect Been Demonstrated? | Relevant Authors (Chapter Number) |
|---|---|---|
| 1. Factors related to rations | | |
| A. New ration | Yes | Baker-Fulco (8), Hirsch (9) |
| B. Broad variety in ration system | Indirectly | Rolls (11), Hirsch (9) |
| C. Variety of caloric drinks | Yes | Engell (12) |
| D. Marketing | No | Thompson (13), Cardello (10) |
| E. Social modeling | Yes | Cardello (10), de Castro (20) |
| 2. Factors related to conditions in the field | | |
| A. Favorable deployment | No | Kramer (17) |
| B. Scheduled meals and snacks | No | Halberg et al. (19), Kramer (17), Schutz (18) |
| C. Sheltered from elements while eating | No | Kramer (17) |
| D. Group eating | Yes | de Castro (20) |
| E. Ensure hydration | Yes | Engell (12) |
| F. Easy ration and beverage heating | Yes | Kramer (17) |

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The dichotomy between factors relevant to the feeding environment and those having to do with the rations also holds when considering which variables appear ready for immediate evaluation as opposed to those that require more time or research before they can be implemented. In this author's view, most of the factors having to do with the feeding environment are well defined and circumscribed in scope. They could be implemented by field commanders and evaluated almost immediately. Conversely, designing a new ration or increasing variety in a current ration (Table 22-1, items 1A, B, and C) imposes the time delay associated with product development. Similarly any effort to market a ration (1D) or to use the social modeling influences of peers and leaders (1E) to affect troop attitudes and consumption only make sense in the context of introducing a new or a much-revised ration. Attempts to alter troop views of a ration that has been shaped, perhaps inalterably, by extensive experience are destined to fail. For this reason efforts to use marketing techniques or social influences require a new ration. In addition, these latter variables, marketing and social influences, although potentially powerful determinants of troop attitudes and behavior, have not been thoroughly researched in the military context. Employing these variables effectively in the military environment will require additional research and/or consultation with marketing and communication experts from the commercial and academic sectors.

The preceding analysis indicates the need for a plan with both short-term and long-term components. In the short term, emphasis will be placed on the field feeding environment, whereas over a longer term the focus will be placed on variables related to rations.

## Short-Term Plans

The first step of the plan will be to hold discussions with senior food service personnel, experienced noncommissioned officers, and field commanders to explore ways to define clearly and implement the factors related to feeding in the field (Table 22-1, items 2A-F). Once consensus is reached on the feasibility and definition of these variables, a field test will be planned and conducted. The most current ration heating and liquid heating devices (2F) will also be included in this field test.

Although it would be preferable to test each of these factors separately to isolate whether they are effective by themselves, several considerations argue against this approach. First, recent reductions in training funds have made it increasingly difficult to find troops to participate in field studies of sufficient duration to evaluate troop food intake adequately in response to changes in rations or, in this case, feeding conditions. It is best to maximize the likelihood of success in any field test. Second, ration field tests are most likely to succeed when the test involves the fewest number of units being exposed to different

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treatments. Third, the types of changes in field feeding that are being tested are not costly and only require informed leadership to create a favorable feeding environment.

For these reasons a less-than-perfect experiment is proposed where one company would be exposed to the full array of changes in the way troops are fed in the field (Table 22-1, items 2A-F). A second company in the same training exercise, with similar activities, would serve as the control group. Both companies would be fed the same ration. To test the role of these situational variables, the current version of a ration or a new one could be used. Ideally this ration would be the most current version of the Meal, Ready-to-Eat (MRE) fed for 3 meals per day for at least 10 days. A group fed 3 MREs/d is more likely to be sensitive to the variables being tested than a group fed a ration mix with hot meals. The nature of hot meals in the field brings troops together in a manner that imposes many of the factors that are being used to improve ration consumption. Also, high intake of a hot meal leaves less margin for improvement in the other meals and renders one of the dependent measures in the test less sensitive.

This field experiment would follow what has become the standard procedure for evaluating military rations. Measures of body weight, food intake, fluid intake, hydration status, and food acceptance would be taken periodically during the training exercise. Troop reactions to the rations and feeding environment would be assessed by final questionnaires and focus groups (see Baker-Fulco and Hirsch, Chapters 8 and 9 in this volume).

A successful outcome in a field study with either a current ration or a new ration would provide strong evidence for the collective influence of these manipulations on ration intake. In the case where a current ration was tested, these changes would have to overcome the steady downward trend in consumption that Kramer (Chapter 17 in this volume) has noted when the same version of the MRE is examined across time in different studies. With a new ration, or a ration that has undergone major modifications, these changes in the feeding environment would have to produce larger changes in food intake and consumer acceptance responses than would be expected from a new product alone (see Baker-Fulco and Hirsch, Chapters 8 and 9 in this volume).

The findings from this study would be brought to the appropriate military agencies for them to consider how these findings could be incorporated into field feeding policy, doctrine, or troop and leadership training to ensure an environment that encourages ration consumption.

## Long-Range Plans

The long-range elements of this plan are contingent on both ration development (Table 22-1, items 1A, B, and C) and programmatic research on

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marketing and social modeling effects (Table 22-1, items 1D and E). For this reason they are tentative and will be outlined in broad terms.

The global strategy for addressing ration-related approaches to overcoming underconsumption is to apply both marketing and social influence to new or revised rations as they become available. When a new product has been developed, ongoing research in these areas will have to be evaluated to judge whether enough has been learned about these factors in a military context to launch a program where they would be used to enhance troop responses to a new ration. Although it is of considerable interest to determine whether troop responses to a new ration are affected by these factors, it is even more critical to determine whether the successful application of marketing and social influence can sustain the initial high level of acceptance and consumption over many field training exercises. Similarly, when attention is directed toward beverage and food variety in a ration (Table 22-1, items 1D and E), the central question is whether high initial acceptance and consumption are sustained by variety in later encounters with the ration in its second or third year. These long-term considerations suggest a new type of ration testing strategy where a test unit will be monitored periodically from the time a new ration is introduced until several years later.

Success in either the short- or long-term components of this plan will eventually mean that the most successful and cost-effective elements of both programs will be combined and institutionalized through policy and training.

## CONCLUSION

The proposal outlined in this chapter represents one of many possible approaches to correcting the ration underconsumption problem. A full discussion of these issues, refinement of the experimental manipulations, and their testing and implementation will call for the concerted effort of many individuals and organizations. This book is a provocative first step in that direction.

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# Appendixes



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# A

# Biographical Sketches

### Committee on Military Nutrition Research

**ROBERT O. NESHEIM (*Chair*)** was Vice President of Research and Development and later Science and Technology for the Quaker Oats Company. He retired in 1983 and was Vice President of Science and Technology and President of the Advanced Health Care Division of Avadyne, Inc. before his retirement in 1992. During World War II, he served as a Captain in the U.S. Army. Dr. Nesheim has served on the Food and Nutrition Board, chairing the Committee on Food Consumption Patterns and serving as a member of several other committees. He also was active in the Biosciences Information Service as its Board Chairman, American Medical Association, American Institute of Nutrition, Institute of Food Technologists, and *Food Reviews International* editorial board. He is a fellow of the American Institute of Nutrition and American Association for the Advancement of Science and a member of several professional organizations. Dr. Nesheim received a B.S. in Agriculture, M.S. in Animal Science, and Ph.D. in Nutrition and Animal Science from the University of Illinois.

**RICHARD L. ATKINSON** is Professor of Internal Medicine, Department of Nutritional Science at the University of Wisconsin-Madison. He was the Associate Chief of Staff for Research and Development at the Veterans'

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Affairs Medical Center in Hampton, Virginia. Concurrently, Dr. Atkinson was Professor of Internal Medicine and Chief of the Division of Clinical Nutrition at the Eastern Virginia Medical School in Norfolk, Virginia. He served 4 years in the military at Walter Reed Army Hospital in Washington, D.C. and the U.S. Army Hospital in Fort Campbell, Kentucky. Dr. Atkinson is an editorial board member for the *Journal of Nutrition* , a medical advisory board member for *Obesity Update*, and a contributing editor for *Nutrition Reviews*. He is a member of the American Association for the Advancement of Science, American Institute of Nutrition, and Endocrine Society; he is a fellow of the American College of Nutrition and American College of Physicians. Dr. Atkinson holds a B.A. from the Virginia Military Institute in Lexington and M.D. from the Medical College of Virginia in Richmond, where he served his internship. He then completed his residency at Harbor General Hospital in Torrance, California.

**WILLIAM R. BEISEL** is Adjunct Professor in the Department of Immunology and Infectious Diseases at the Johns Hopkins School of Hygiene and Public Health. He held several positions at the U.S. Army Medical Research Institute for Infectious Diseases at Fort Detrick, Maryland, including in turn, Chief of the Physical Sciences Division, Scientific Advisor, and Deputy for Science. He then became Special Assistant for Biotechnology to the Surgeon General. After serving in the U.S. military during the Korean War, Dr. Beisel was the Chief of Medicine at the U.S. Army Hospital in Ft. Leonard Wood, Missouri, before becoming the Chief of the Department of Metabolism at the Walter Reed Army Hospital. He was awarded a Commendation Ribbon, Bronze Star for the Korean War, Hoff Gold Medal at the Walter Reed Army Institute of Research, B. L. Cohen Award of the American Society for Microbiology, and Department of Army Decoration for Exceptional Civilian Service. He was named a diplomat of the American Board of Internal Medicine and a fellow of the American College of Physicians. In addition to his many professional memberships, Dr. Beisel is a *Clinical Nutrition* contributing editor and *Journal of Nutritional Immunology* editor. He received his A.B. from Muhlenberg College in Allentown, Pennsylvania, and M.D. from the Indiana University School of Medicine.

**GAIL E. BUTTERFIELD** is Director of Nutrition Studies at the Geriatric Research, Education, and Clinical Center of the Palo Alto Veterans Administration Medical Center in California. Concurrently, she is Lecturer in the Department of Medicine, Stanford University Medical School, and Visiting Assistant Professor in the Department of Human Biology, Stanford University. Her previous academic appointments were at the University of California-Berkeley. Dr. Butterfield belongs to the American Institute of Nutrition, American Dietetic Association, and American Physiological Society. As a fellow of the American College of Sports Medicine, she serves on the Position

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Stands Committee and the editorial board for *Medicine and Science in Sports and Exercise*. She also was the Past President and Executive Director of the Southwest Chapter of that organization and an Ad Hoc Member for the Respiratory and Applied Physiology Study Section of the National Institutes of Health. Dr. Butterfield received her A.B. in Biological Sciences, M.A. in Anatomy, and M.S. and Ph.D. in Nutrition from the University of California-Berkeley.

**JOHN D. FERNSTROM** is Professor of Psychiatry, Pharmacology, and Behavioral Neuroscience at the University of Pittsburgh School of Medicine, and Director, Basic Neuroendocrinology Program at the Western Psychiatric Institute and Clinic. He received his S.B. in Biology and his Ph.D. in Nutritional Biochemistry from the Massachusetts Institute of Technology (M.I.T.). He was a Post-doctoral Fellow in Neuroendocrinology at the Roche Institute for Molecular Biology in Nutley, New Jersey. Before coming to the University of Pittsburgh, Dr. Fernstrom was an Assistant and then Associate Professor in the Department of Nutrition and Food Science at M.I.T. He has served on numerous governmental advisory committees. He presently is a member of the National Advisory Council of the Monell Chemical Senses Center and is chairman of the Neurosciences Section of the American Institute of Nutrition. He is a member of numerous professional societies, including the American Institute of Nutrition, the American Society for Clinical Nutrition, the American Physiological Society, the American Society for Pharmacology and Experimental Therapeutics, the American Society for Neurochemistry, the Society for Neuroscience, and the Endocrine Society. Among other awards, Dr. Fernstrom received the Mead-Johnson Award of the American Institute of Nutrition, a Research Scientist Award from the National Institute of Mental Health, a Welcome Visiting Professorship in the Basic Medical Sciences, and an Alfred P. Sloan Fellowship in Neurochemistry. His current major research interest concerns the influence of the diet and drugs on the synthesis of neurotransmitters in the central and peripheral nervous systems.

**JOËL A. GRINKER** is Professor of Pediatrics and Communicable Diseases at the School of Public Health, University of Michigan-Ann Arbor. She is a member of the university's Center for Human Growth and Development and served as Director of the Program in Human Nutrition. She was Visiting Scientist at the USDA Human Nutrition Research Center on Aging at Tufts University in Boston and Visiting Associate Professor at the Lavaratoire de Neurophysiologie Sensorielle et Compartmental, College de France, Paris. Currently, she is a reviewer for the National Cancer Institute, National Institutes of Health, and National Science Foundation and for several professional journals. She serves on the editorial boards for *Appetite, Journal of Eating Disorders,*, and *Psychosomatic Medicine*. She is a fellow of the American Psychological Association, American Association for the Advancement

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of Science, and New York Academy of Sciences and is a member of several professional societies. Dr. Grinker holds a B.A. in Psychology from Wellesley College in Massachusetts and Ph.D. in Experimental Social Psychology from New York University. At Rockefeller University, she was a Russell Sage Post-doctoral Fellow in the Laboratory of Human Behavior and Metabolism of Dr. Jules Hirsch and then Assistant and Associate Professor.

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**ORVILLE A. LEVANDER** is Research Leader for the U.S. Department of Agriculture (USDA) Vitamin and Mineral Nutrition Laboratory in Beltsville, Maryland. He was Research Chemist at the USDA's Human Nutrition Research Center, Resident Fellow in Biochemistry at Columbia University's College of Physicians and Surgeons, and Research Associate at Harvard University's School of Public Health. Dr. Levander served on the Food and Nutrition Board's Committee on the Dietary Allowances. He also served on the National Research Council's Committee on Animal Nutrition and Committee on the Biological Effects of Environmental Pollutants. He was a member of the U.S. National Committee for the International Union of Nutrition Scientists and temporary advisor to the World Health Organization's Environmental Health Criteria Document on Selenium. Dr. Levander was awarded the Osborne and Mendel Award for the American Institute of Nutrition. His society memberships include the American Institute of Nutrition, American Chemical Society, and American Society for Clinical Nutrition. Dr. Levander received his B.A. from Cornell University and his M.S. and Ph.D. in Biochemistry from the University of Wisconsin-Madison.

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Dr. Dwyer is the immediate past President of the American Institute of Nutrition, past Secretary of the American Society for Clinical Nutrition, and past President and current Fellow of the Society for Nutrition Education. She served on the Program Development Board of the American Public Health Association from 1989 to 1992 and is a member of the Food and Nutrition Board of the National Academy of Sciences, the Technical Advisory Committee of the Nutrition Screening Initiative, and the Board of Advisors for the American Institute of Wine and Food. As the Robert Wood Johnson Health Policy Fellow (1980–1981), she served on the personal staffs of Senator Richard Lugar (R-Indiana) and Senator Barbara Mikulski (D-Maryland).

Dr. Dwyer has received numerous honors and awards for her work in the field of nutrition, including the J. Harvey Wiley Award from the Society for Nutrition Education. She was invited to give the Lenna Frances Cooper Lecture at the annual meeting of the American Dietetic Association in 1990. Dr. Dwyer is currently on the Editorial Advisory Board for *Clinics in Applied Nutrition* and is a Contributing Editor for *Nutrition Reviews* as well as a reviewer for the *Journal of the American Dietetic Association* and the *American Journal of Public Health*. She received her D.Sc. and M.Sc. from the Harvard School of Public Health, an M.S. from the University of Wisconsin, and completed her undergraduate degree with distinction from Cornell University.

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Medicine, and Goucher College. Her areas of research interest include bioenergetic modeling, trace mineral nutrition, and ingestive behavior in human and nonhuman primates.

## Authors

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**PHILIP BRANDLER** is a member of the Army Acquisition Corps and serves as the current Director of Sustainability at the U.S. Army Natick Research, Development and Engineering Center (Natick) in Massachusetts in charge of all troop quality-of-life items. At Natick, he held positions as the Director of Food Engineering, the Assistant to the Technical Director for Program Integration, Deputy to the Commander for Installation Operations, Director of Systems Analysis and Concept Development, and Chief of Operations Research/Systems Analysis. Prior to Natick, Mr. Brandler worked for the National Aeronautics and Space Administration Electronics Research

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Center, the Air Force Cambridge Research Labs, and the Massachusetts Institute of Technology. His accomplishments have been recognized with the Technical Director's Gold Pin Award for Research, the Colonel Rohland A. Isker Award from Research and Development Associates, the TROSCOM Leadership Award, the Ten Outstanding AMC Personnel of the Year Award, the Decoration for Meritorious Civilian Service, and the Decoration for Exceptional Civilian Service. He is a member of the Operations Research Society of America, the Military Operations Research society, and the Institute of Food Technologists. Mr. Brandler received his Bachelor's Degree in Physics from Columbia University and holds Advanced Degrees in Physics, Industrial Engineering/Operations Research, and Business Administration from Brown University and Northeastern University.

**ARMAND V. CARDELLO** is a Research Psychologist in the Behavioral Sciences Division at the U.S. Army Natick RD&E Center in Natick, Massachusetts. Dr. Cardello received his A.B. in Psychology at Dartmouth College and his M.A. and Ph.D. in Psychology at the University of Massachusetts at Amherst. In addition to his numerous scientific publication in the areas of human psychophysics and consumer food acceptance, he is a member of the Editorial Boards of the *Journal of Sensory Studies* and *Food Quality and Preference* and is contributing columnist for *Cereal Foods World*. Dr. Cardello's current research interests are in the areas of sensory psychology, consumer research, and the psychological factors controlling food choice and acceptance.

**GERMAINE CORNÉLISSEN** is Director of Biometry at the Chronobiology Laboratories of the University of Minnesota. With Dr. Franz Halberg, she coordinates the International Womb-to-Tomb Chronome Initiative. She is co-editor of the journal *Chronobiologia* and serves on the board of the International Society for Research on Civilian Diseases and the Environment (SIRMCE). She is also a member of several professional organizations. Dr. Cornélissen received a master's in Physics and in Education and a Ph.D. in Physics from the University of Brussels, Belgium.

**GERALD A. DARSCH** is the Chief of the Ration Systems Division, Sustainability Directorate, U.S. Army Natick Research Development and Engineering Center in Natick, Massachusetts. He directs and coordinates a broad food program involving innovative research, development, production engineering, and standardization activities. Prior to his current assignment, he was a special assistant for the Department of Defense Food Program and a food technologist. Mr. Darsch has received the U.S. Army Material Command Top Ten Award, Operation Desert Shield/Storm (Commander, AMC) Award, Meritorious Civilian Service Award, Superior Civilian Service Award, Technical Director's Gold Pins For Excellence in Research and in Engineering,

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# B

# Abbreviations

| | |
|---|---|
| ACM | acute mountain sickness |
| ADH | anti-diuretic hormone |
| AFFS | Army Field Feeding System |
| AFFS-F | Army Field Feeding System-Future |
| ANOVA | analysis of variance |
| APFT | Army Physical Fitness Test |
| APFRI | Army Physical Fitness Research Institute |
| AR 40-25 | Army Regulation 40-25 |
| BMR | basal metabolic rate |
| BSA | brigade support area |
| CFFS-FDTE | Combat Field Feeding System-Force Development Test and Experimentation |
| CID | cold-induced diuresis |
| CIVD | cold-induced vasodilation |
| CMNR | Committee on Military Nutrition Research |
| CNS | central nervous system |
| DoD | Department of Defense |
| DSM-IV | Fourth Edition of the Diagnostic and Statistical Manual for Mental Disorders |
| EKD | eucaloric ketogenic diet |

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| | |
|---|---|
| ERPF | effective renal plasma flow |
| FDA | U.S. Food and Drug Administration |
| FNB | Food and Nutrition Board |
| HACE | high altitude cerebral edema |
| HAPE | high altitude pulmonary edema |
| HQDA | Headquarters, Department of the Army |
| HMV | high mobility vehicle |
| ILE | isokinetic leg extension |
| IOM | Institute of Medicine |
| JSORF | Joint Armed Services Operational Ration Forum |
| KCLFF | Kitchen Company Level Field Feeding equipment |
| KCLFF-E | Kitchen Company Level Field Feeding-Enhanced equipment |
| LAIR | Letterman Army Institute of Research |
| LBM | lean body mass |
| LLRP | Long Life Ration Packet |
| MCI | Meal, Combat Individual |
| METT-T | Mission, Enemy, Troops, Terrain, and Time |
| MFM | Multi-Faith Meal |
| MKT | mobile kitchen trailer |
| MMWTC | Marine Mountain Warfare Training Center |
| MND | Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine |
| MOS | Military Occupational Specialty |
| MRDAs | Military Dietary Allowances |
| MRE | Meal, Ready-to-Eat |
| NCO | noncommissioned officer |
| NFCS-CSFII | Nationwide Food Consumption Survey-Continuing Survey of Food Intakes by Individuals |
| NRC | National Research Council |
| NRDEC | U.S. Army Natick Research, Development and Engineering Center |
| OCS | Officer Candidate School |
| ODCSLOG | Office of the Deputy Chief of Staff of Logistics |
| ODS | Operation Desert Shield/Storm |
| OTSG | Office of the Surgeon General of the Army |
| PCA | principle component analysis |
| QMC&S | U.S. Army Quartermaster Center and School |
| RCW | Ration, Cold Weather |
| RDAs | Recommended Dietary Allowances |
| RDTE&E | Food Research Development Test Evaluation and Engineering Program |
| REM | rapid eye movement |
| RLW | Ration, Light Weight |

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| | |
|---|---|
| RLW-30 | Ration, Light Weight 30-days |
| RQ | respiratory quotient |
| SC | sanitation center |
| SEP | Soldier Enhancement Program |
| SRC | U.S. Army Subsistence Review Committee |
| STO | Science and Technology Objective |
| TBARS | thiobarbituric acid-reacting substances |
| TEF | thermogenic effect of feeding |
| T Ration | Tray Ration |
| UGR | Unitized Group Ration |
| USACDEC | U.S. Army Combat Developments Experimentation Center |
| USAMRDC | U.S. Army Medical Research and Development Command |
| USARMRMC | U.S. Army Medical Research and Materiel Command |
| USANRDEC | U.S. Army Natick Research, Development and Engineering Command |
| USARIEM | U.S. Army Research Institute of Environmental Medicine |
| USDA | U.S. Department of Agriculture |
| $\dot{V}_{o2}$ max | maximal oxygen uptake |

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# C

# Factors Related to Underconsumption—A Selected Bibliography

On the following pages is a selection of references dealing with the factors related to the underconsumption of military operational rations. This bibliography was compiled from the joint reference lists of the 22 chapters in this report, selected references from a limited literature search, and references recommended by the invited speakers as background reading for the workshop participants. As a result, references that are historical in nature are included in this listing with the most current studies on factors related to underconsumption.

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