

PROTEIN INTAKE, BODY COMPOSITION AND ATHLETIC PERFORMANCE

by

JENNIFER A. CASE

B.S., Washburn University, 2005  
M.S.E., University of Kansas, 2007

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Human Nutrition  
College of Human Ecology

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

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## **Abstract**

**Background:** Mixed Martial Arts (MMA) is a growing sport that places competitors into specific weight classes to level the competition field. Athletes “cut weight” to compete in a weight class lower than their “walk around” weight. Techniques for cutting weight include dehydration, starvation and exercise in hot environments jeopardizing health and performance. Higher-protein diets (HPD) have been shown to improve weight loss by increasing satiety, thermogenesis, decreasing total energy intake, and maintain lean mass during periods of energy deficiency, such as weight loss. Research regarding the impact of HPD on performance is limited and conflicting.

**Specific Aims:** The central hypothesis for this study was: HPD diets will elicit greater weight loss and enhance body composition compare to tradition low-fat diets in non-obese, active individuals. The three specific aims of this study are: 1) examine the effects of HPD on weight loss, 2) evaluate the impact of HPD of athletic performance, and 3) determine the effectiveness of HPD for accelerated weight loss.

**Methods:** Military personnel participating in the Combatives program were recruited. Participants were assigned a HPD (40% CHO, 30% PRO, 30% fat), traditional low-fat, high-carbohydrate diet (65% CHO, 15% PRO, 20% fat), or an ad libitum diet for 12-day to 6-weeks depending on their training program. Fields tests for pre- and post-intervention measures of performance included: vertical jump and leg power index to measure explosive power, 600 meter shuttle run for anaerobic capacity and 1.5 mile run for aerobic capacity. Pre- and post-intervention of weight and body composition were determined using dual energy x-ray

absorptiometry. Diet analysis software was used to determine nutrient intakes during the study. SPSS statistical software was used to determine descriptive statistics, paired t-tests, Pearson's Correlations and one-way ANOVA.

**Results & Conclusions:** Due to the unanticipated high rate of dropout, statistical significance was difficult to determine, however, there was a trend for the HPD to elicit fat-free mass retention and it not negatively impact performance. Discrepancies in energy and nutrient intake made dietary comparison difficult. Future studies with larger samples and greater dietary control are needed to further evaluate the research goals of this study.

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Approved by:

Major Professor  
Mark Haub

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## **Dedication**

The project is dedicated to my family and friends. I thank you all for your patience and guidance during the dissertation process and during the last 10 years of my college career.

## Preface

This project began by combining two of my passions: education and Mixed Martial Arts (MMA). These two passions have been interwoven for the last nine years of my life. My undergraduate degree was originally mass media, specifically graphic design. After my first year as an undergrad (summer 2001), I began taking Hawaiian Kempo. I became thoroughly enthralled with karate and began training every day. My karate school also offered classes in a sport I had never heard of, Brazilian jujitsu. I took one Brazilian jujitsu class and was hooked. I ended up changing my major to athletic training so I could learn how to mend competitors after I injured them using ju jitsu.

I began competing in amateur jujitsu matches in 2002. By November of 2002, I had won the United States Sport Ju Jitsu competition and I was a member of the United States World Team that traveled to Uruguay to represent the United States in the World Games. Disappointingly, during the World Games I was disqualified for excessive force. As I was leaving the competition arena my karate instructor grabbed me and said, “Forget the amateur stuff. You're going Pro.” I began training for professional MMA and in 2004 I competed in my first professional MMA match. It lasted just under three minutes, with me winning by an arm-bar submission.

The rest, as they say, is history. I competed in professional MMA for the rest of my undergraduate and graduate career. In 2007 I began my graduate degree at the University of Kansas in sports studies. That same year, I won the Fatal Femmes World Middle Weight Title in professional MMA. After graduating from KU in 2008, I moved to Manhattan to earn a doctorate degree from Kansas State University in human nutrition, focusing on diet and performance. I began training at a ju jitsu school in Manhattan, Combative Sports Center. This school not only

had four Brazilian ju jitsu brown belt instructors, it also taught the Military Combatives to Fort Riley soldiers and the K-State Army and Air Force ROTC.

In 2008, I was asked to help train the soldiers. After helping train the soldiers for about six months, I was asked to create a simple diet plan (Appendix B) for the competition team that was beginning a six-week training program leading up to the All Army Combatives Tournament in 2008. The Combatives Tournament is divided up into weight classes: 125 pounds and below, 140 pounds and below, 155 pounds and below, 170 pounds and below, 185 pounds and below, 205 pounds and below and above 205 pounds. I was given short notice, but I came up with a very basic diet plan focusing on a balanced diet with a moderate intake of protein using general guidelines from [mypyramid.gov](http://mypyramid.gov). I used also performed Dual energy X-ray absorptiometry (DEXA) body scans to determine initial body compositions and possible fight weight for the competitors based on their fat-free mass. A few of the participants completed another body scan upon completion of the six-week training program. I used the information from the body composition scans as a case study to provide some insight into the body composition changes of athletes during a six-week training program leading up to a competition. A major limitation to that pilot project was the lack of post-intervention diet records.

This team took taking first place. This was the first time the Fort Riley All Army Combatives team won the competition. I was given an Award of Appreciation from the United States Army for by contribution to the Combatives Team. In 2009, I again was asked to design a diet plan for the competition team. I had begun researching diets with different macronutrient distribution to determine which might have the best outcome for athletes needing to decrease their weight, but still perform at optimum capacity. Research available at that time indicated a higher-protein diet, one with 30 percent of the total calories coming from protein or about 2

grams of protein per kilogram body weight, was beneficial for maintaining fat-free mass during periods of energy deficit or weight loss. I was not finding any conclusive evidence reporting performance detriments associated with a higher-protein diet. Thus, I wanted to examine the effectiveness of a higher-protein diet on body composition changes and athletic performance in ju jitsu and MMA.

I had had a unique opportunity in the summer of 2009 to not only work with the all Army Combatives Team but also the ROTC program participates in Military Combatives. The All Army Team was completing a six-week training program, while the ROTC program only completed a 14-day training program. From May 2009 to September 2009, I worked with both groups to implement the higher-protein diet to observe possible changes in performance and body composition. I also was curious about the impact of the differing time frames for the training programs. I used the data collected for these groups to develop the chapters of this report.



## **CHAPTER 1 - Benefits of a Higher-Protein Diet for Individuals in Sports Requiring Weight Classes.** Case, JA, Haub, MD

Despite NCAA regulations against “weight cutting,” athletes competing in wrestling and other weight class sports still participate in dangerous methods of rapid weight loss in order to compete in a lower weight class [1, 2, 3]. The intention of these athletes is to use weight loss as an ergogenic aid, intending to give them a strength and size advantage over their opponent. However, what they are really doing is hindering their performance and putting their health at risk.

Higher-protein diets (HPD) may be an effective alternative to traditional weight cutting practices. Typically, HPD have 30 percent or more of total calories coming from dietary protein intake, and they have been shown to induce greater weight loss by increasing satiety and thermogenesis and decreasing energy intake, even in an ad libitum environment. A key advantage of HPD is the maintenance of fat-free mass, even during periods of limited energy intake [4, 5, 6, 7]. However, this concept has not been well examined in athletes competing in weight class sports. The continued use of hazardous weight cutting methods and lack of nutritional knowledge available to coaches and athletes demonstrates the need for a closer examination of this issue. The purpose of this review article is to examine the possibility of using a HPD (consisting of 40 percent carbohydrates, 30 percent protein and 30 percent fat) to enhance weight loss and body composition in athletes competing in weight class sports with less affect on their performance.

## **Introduction**

Striving for a competitive edge is an essential part of sports participation at every level. This can range from different training techniques, nutritional habits and weight loss methods. Wrestlers, boxers, and mixed martial arts (MMA) fighters all must make a certain weight to compete in their given sport. Due to this weight requirement, weight loss or “weight cutting” is an inevitable and almost expected part of participation in these sports [3, 8]. Current weight cutting methods not only hinder athletic performance, but may also put the athlete’s health in jeopardy [2, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. Many athletes and coaches, regardless of their level of competition, lack the nutritional knowledge necessary to safely lose weight at an accelerated pace [9, 22]. In 1997, three collegiate wrestlers died while attempting to rapidly lose weight using weight cutting methods that are still used by athletes today [16]. Since cutting weight is an engraved aspect of training in weight class sports, healthier alternatives for rapid weight loss need to be identified.

## **Current Weight Cutting Techniques**

Of the forms of rapid weight loss regularly practiced by athletes, dehydration, food restriction and exercising in a hot environment are the most prominent [2, 3, 8, 19, 21]. In extreme cases, some athletes actually resort to self-induced vomiting and the use of diuretics and laxatives to lose weight prior to their weigh-in [2]. It is not uncommon for high school and collegiate wrestlers to lose 5 to 10 percent of their body weight through dehydration during the 24 to 36 hours prior to their event [3, 19, 21]. Wrestlers and coaches often perceive dieting and dehydration to be the same thing [23].

To highlight the health risks, the aforementioned weight cutting fatalities occurred when the wrestlers were attempting to make their weight class via extreme dehydration [16]. Each wrestler was attempting to lose more than 10 pounds in less than 72 hours by using food and fluid restriction and vigorous exercise in a hot environment. After multiple hours of exercise, each athlete went into cardiopulmonary arrest and did not recover [16]. The NCAA has since established regulations for the amount of weight that can be lost from preseason to in-season competition. However, unsafe weight practices are still occurring [2, 3]. It is also important to mention that amateur and professional sports, such as jujitsu, MMA and boxing, do not have regulations like those imposed by the NCAA regarding the amount of weight that can be cut prior to an event. Consequently, while high school and collegiate athletes might be better protected, those competing outside of the academic setting may lack nutritional regulations.

Houston et al (1981) performed a study on four Olympic wrestlers during their competitive season. Each wrestler was given 48 hours to perform typical weight cutting practices. During the first 24 hours, each wrestler decreased food intake by 66 percent. During the next 24 hours, the food restriction remained in place and water intake was decreased by two-thirds over a 48-hour period. Athletes lost an average of 2.2 percent of their body weight during the first 24 hours and another 4.7 percent during the second 24-hour period. The participants of this study performed physical tests before and after the weight cutting period. The results of this study found that muscular strength was most impacted by such rapid weight loss. It is interesting that this study found that rapid weight loss did not affect aerobic or anaerobic performance. Other researchers have reported that rapid weight loss via dehydration had a negative impact on muscular strength, as well as aerobic and anaerobic capacity [13, 18, 19, 20, 24].

Klinzing et al (1986) performed a similar rapid weight loss study, but only used dehydration methods either via excessive exercise and a hot environment or the use of diuretics and laxatives. This study found that athletes lost 5 percent of their initial body weight in just 50 hours, which is not uncommon during the wrestling season. Physical testing for this study showed that rapid weight loss through dehydration decreased maximal oxygen uptake, decreased time to exhaustion and increased heart rate during exercise, all of which resulted in a negative impact on endurance performance. Similarly, Webster et al (1990) found that wrestlers performing rapid weight loss via dehydration resulted in decreased muscular strength, anaerobic power and aerobic performance. Considering these factors, typical weight-cutting tactics led to decreased performance, with no studies showing improved performance after weight loss.

Extreme food restriction or prolonged hypocaloric dieting can also result in a significant decrease in strength and performance [4, 11, 14, 15, 17, 25, 26]. The American College of Sports Medicine, American Dietetic Association and the Dietitians of Canada released a joint position statement in 2009 recommending that athletes in weight class sports refrain from dehydration and food restriction, stating that it would negatively impact performance and overall health. Coaches were reminded that athletic performance cannot be predicted by body composition alone, as natural ability and training play a substantial role in the overall performance. Despite the position statement, athletes regularly take part in caloric restriction to reach a certain weight class.

During prolonged periods of caloric restriction, one's resting energy expenditure can decrease [27], resulting in greater difficulty during weight loss. Also, prolonged periods of food deprivation can result in binge eating, which exacerbates the weight cycling that is prevalent in wrestling [2, 8]. Frequent weight cycling results in an increase of the amount of weight being

held in the abdominal region [23, 28]. This can result in an increased risk of developing central adiposity and associated chronic diseases. Chronic weight cyclers also are at an increased risk of developing lifelong disordered eating, particularly bulimia nervosa and binge eating [2, 8]. In 1991, the NCAA reported that 7 percent of male wrestlers have disordered eating, which is significantly greater than the 0.1 percent of males in the general population who have an eating disorder [8].

Two interesting studies regarding caloric restriction in wrestlers were performed by Horswill et al (1990) and O'Conner et al (2007). These studies not only manipulated caloric intake, but they also reported the differences in macronutrient distribution of the hypocaloric diets. Both studies reported that caloric restriction negatively impacted performance, especially sprinting and anaerobic performance. However, O'Conner et al reported that the use of a higher-protein diet elicited spontaneous caloric restriction, without negatively impacting performance as seen with other hypocaloric diets. Mourier et al (1996) reported similar results as O'Conner et al. In a study involving the French national wrestling team, Mourier and colleagues manipulated calorie and protein intake. It was found that a hypocaloric diet containing higher levels of protein resulted in greater fat-mass loss, particularly visceral fat, without affecting performance variables. These studies seem to support the use of a higher-protein diet for athletes competing in weight-restrictive sports.

### **Higher Protein as an Alternative**

As mentioned previously, a possibly safer alternative to current weight cutting practices is the use of higher-protein diets for accelerated weight loss. A diet similar to the Zone diet may be most beneficial because the macronutrient breakdown, consisting of 40 percent carbohydrates, 30 percent protein and 30 percent fat, is less restrictive than other high-protein diets, such as the

Atkins diet. The Atkins diet limits carbohydrate intake to 50 grams or less daily [29]. The Zone diet also is beneficial because it provides an adequate amount of fat to support body processes, according to the Acceptable Macronutrient Distribution Ranges (AMDR) established by the USDA. Many diets that are low in carbohydrates are also high in dietary fat [29].

Horswill et al (1990) reported an exacerbation of performance detriments when on a high-fat diet. This is not a novel finding. Various studies examining low-carbohydrate diets that were high in fat found them to have a negative impact on performance [30, 31, 32, 33, 34]. These studies examined endurance performance, not anaerobic or strength performance, which is the prevalent type of activity performed in weight restricted sports. Dipla et al (2008) reported that isoenergetic diets composed of higher protein did not impact resistance-performance parameters, indicating that anaerobic performance may not be inhibited when on a hypocaloric, higher-protein diet.

Additionally, higher-protein diets have been shown to enhance weight loss by increasing satiety and thermogenesis and decreasing subsequent energy intake [36, 37, 38, 39, 40, 41]. The increase in thermogenesis is caused by an increase in the thermic affect of food, which results in greater caloric expenditure during the process of metabolism [37, 38, 41]. Traditional low-fat, high-carbohydrate diets used for weight loss cause a decrease in thermogenesis by lowering the thermic affect of food. Carbohydrates only require 5 to 10 percent of total caloric intake to be used for energy during digestion, while protein uses 20 to 30 percent of caloric intake for energy production during digestion [41]. The increase in thermogenesis can result in increased satiety and decreased subsequent food intake. It has been reported that increasing the dietary protein to 30 percent or more of one's total caloric intake can result in decreased ad libitum food intake

because of greater satiety [37,38,39,40]. This amount of protein is still within the AMDR for dietary protein intake.

Lanter et al (1999) compared three different liquid lunches: high-protein, consisting of 9.5 percent carbohydrates, 71.5 percent protein and 19 percent fat; mixed-intake, consisting of 55 percent carbohydrates, 36 percent protein and 9 percent fat; and high-carbohydrate, consisting of 99 percent carbohydrates, 0 percent protein and 0 percent fat. The satiety effects of protein were apparent after just one meal. Subjects in the high-protein and mixed-intake groups took in significantly less calories in their next meal than the high-carbohydrate group. In a review article by Veldhorst et al (2008), the initial satiety effect of protein is reported to continue for as long as subjects remained on the higher-protein diet. It has been shown that higher-protein diets have greater participant adherence than other diets manipulating macronutrient distribution [41,42]. Westman et al (2002) reported that subjects on a higher-protein diet found it easier to adhere to the diet after six months, compared to individuals on a typical low-fat, high-carbohydrate diet for weight loss. The chronic satiety paired with greater dietary adherence is beneficial for weight loss.

Another advantage of higher-protein diets is the improvement seen in body composition. After just one week of a higher-protein diet, subjects tend to experience an improvement in body composition as fat mass is decreased and lean mass is retained [41]. Maintenance of fat-free mass while on a higher-protein diet can be seen with or without exercise [5, 39, 44]. Layman et al (2005) compared four different diet groups over a four-month period. Of the four groups, two consumed a higher-carbohydrate diet, consisting of 55 percent carbohydrates, 15 percent protein and 30 percent fat, and two consumed a higher-protein diet, consisting of 40 percent carbohydrates, 30 percent protein and 30 percent fat. Exercise was implemented in one group

from each diet pair. The results indicated that the two protein groups, one that exercised and one that did not, maintained the most lean-mass, while significantly decreasing fat-mass. The combination of exercise and a higher-protein diet resulted in an increase in fat-free mass. This is an important point because the traditional low-fat, high-carbohydrate diet with or without exercise results in significant lean-mass loss [44]. This is problematic since the goal of weight loss is to lose fat-mass, not muscle mass.

Lemon et al (1997) reported that even though many athletes take in more protein than the recommended 1.2 to 1.8 grams per kilogram body weight, athletes that undergo caloric restriction need to increase their protein intake above the recommended amount in order to maintain their fat-free mass. Phillips et al (2006) estimated that a minimum of 27 percent of total calories, or at least 100 grams of protein, is required during caloric restriction to maintain fat-free mass. The addition of resistance exercise to a hypocaloric, higher-protein diet can result in an enhancement of muscle mass while decreasing fat-mass [44, 46].

A common concern for athletes consuming a low-carbohydrate diet is low muscle glycogen. It has been speculated that muscle glycogen levels can be a predictive factor for athletic performance [47]. Studies have shown that the best way to maximize muscle glycogen levels is a post-workout meal that combines carbohydrates and protein [48, 49]. A diet like the Zone diet would contain enough carbohydrates to meet post-workout nutrient requirements. It is important to note that studies have indicated that exercising in a carbohydrate-depleted state causes the body to adapt to such conditions [50, 51] by increasing mitochondria density, which allows for greater oxidation of fatty acids for energy production [50, 51]. Also, studies have shown that when carbohydrate intake is low, dietary protein oxidation occurs at a greater rate,



allowing for sustained energy production [52, 53]. This allows working muscle to continue working at a higher level when consuming a low-carbohydrate diet.

While higher-protein diets may provide performance and/or weight loss benefits, it is important to discuss the impact of these diets on renal health. Due to the prevalence of self-induced dehydration in weight restricted sports, the additional stress of a higher-protein diet on the kidneys can be harmful. However, this concern typically arises when an individual is in a ketogenic state due to carbohydrate restriction. The human body requires 100 to 125 grams of carbohydrates daily to prevent ketosis [54]. During ketosis, the systemic pH of the body can decrease, which can damage internal organs [54]. The Zone diet easily provides adequate carbohydrates to prevent ketosis from occurring by allotting for 30 percent of one's total caloric intake to come from carbohydrates, thus decreasing any potential health risk to the kidneys. Another concern is the increased levels of urea and creatine seen when consuming elevated amounts of dietary protein. Souza et al (2009) reported that increased levels of urea and creatine did not negatively impact renal health in exercising rats [55].

## **Summary**

In conclusion, current rapid weight loss techniques can be harmful to an athlete's health and overall performance. Despite regulations established by a few athletic governing bodies, unhealthy weight cutting practices still occur due to their acceptance in weight class sports. Higher-protein diets may be an alternative for accelerated weight loss with a less of a negative impact on sports performance. There are serious health risks associated with starvation and rapid dehydration currently used in weight cutting; such risks are non-existent or greatly reduced with higher-protein diets. Accelerated weight loss is an inevitable part of participation in weight

restricted sports; however, rather than starvation and dehydration, an athlete may be able to use a higher-protein diet to reach their weight loss goals.

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## CHAPTER 2 - Air Force ROTC Modern Combatives Article

### Use of Higher-Protein Diets During Intense Military Training to Decrease Lean Tissue Loss and Improve Performance.

Case, JA, Haub, MD, Teeter, A, Hubach, K

#### Abstract

*Background:* Current dietary intakes of active military personnel during intense training sessions may result in loss of lean tissue mass due to lower intake of energy and protein.

*Hypothesis:* It was hypothesized that a higher-protein diet (HPD) with frequent meals would result in greater lean tissue maintenance and improved performance during intense military training.

*Design:* 36 Air Force cadets completed a 12-day training session. A HPD (40% carbohydrate, 30% protein, 30% fat) with frequent meals was prescribed to each participant. Cadets completed 4 hours of supervised exercise daily. Pre- and post-test assessments included: body weight, body composition, explosive power testing via vertical jump height and leg power index (LPI) and anaerobic testing via 600m shuttle run.

*Results:* A negative correlation was found between the change in average vertical jump height and protein intake. Total body mass increased by  $0.6 \pm 1.1$  kg ( $p < .001$ ), and percent body fat decreased by  $1.1 \pm 0.9$  ( $p < .001$ ). Fat-free mass increased by  $1.3 \pm 1.1$  kg ( $p < .001$ ), fat-mass decreased by  $0.7 \pm 0.7$  ( $p < .001$ ). Averaged 600 meter times decreased by  $1.2 \pm 1.8$  seconds ( $p < .001$ ). Peak LPI (LPI) and average LPI increased by  $0.12 \pm 0.22$  ( $p < .001$ ) and  $0.13 \pm 0.22$  ( $p < .001$ ), respectively. Total energy intake was  $14,110 \pm 4,389$  kJ. Macronutrient breakdown of diets was  $52 \pm 11\%$  carbohydrates ( $437 \pm 155$  g),  $19 \pm 4\%$  protein ( $157 \pm 65$  g) and  $32 \pm 9\%$  fat ( $119 \pm 53$  g). There was no correlation between meal frequency and anthropometric changes or performance changes. Meal frequency consisted of 64% of the subjects consuming 3 meals and 1 to 3 snacks daily, 22% of

the subjects only consumed 2 meals and 1 to 3 snacks daily, and 13% of participants reported consuming 2 large meals and no snacks daily. *Conclusion:* Frequent meals and snacking appears to have resulted in maintenance and an increase in fat-free mass. The increase in LPI may be partially due to the increase in FFM. However, due to lack of dietary adherence, the hypothesis of this study could not be tested accurately.

## **Introduction**

Military personnel put themselves in extreme danger on a daily basis. In order to prepare for such an excruciatingly difficult job, they must go through rigorous training programs. Many of these training programs last for weeks or months and require hours of physical exertion daily. Without proper nutritional intake, soldiers can suffer a detriment to their body composition, resulting in extreme loss of fat-free mass (FFM). Food frequency questionnaires and diet records have been used to assess the nutrient intake of soldiers in training [1]. It has been shown that military personnel taking part in the Army Ranger Training Program, typically eat a moderate-calorie (~2900 kcal) diet that is lower in carbohydrates (~42%) and high in fat (~38%) [1]. The average protein intake for soldiers during that high-intensity training program is only 18 percent or less of their total calories [1].

There are two main concerns with this type of diet. One is that 2,900 calories might not be enough energy for a soldier who is exercising three to six hours a day. Based on the anthropometric measurements of soldiers reported by Duester [2003] and measurements of military personnel collected at Kansas State University, the average active duty male seems to require a minimum of 3,500 calories daily to maintain weight. When soldiers voluntarily put themselves on a low-calorie diet, loss of FFM can occur [2, 3], which may result in a decrease in

training performance. Prolonged hypocaloric diets result in decreased strength and power output, even in highly trained individuals [4, 5].

Another problem with the current reported dietary intake of soldiers is that they are low in protein. The average dietary protein intake of training personnel has been reported to be only 135 grams per day, which is roughly 18 percent of their total caloric intake [1]. This level of intake is roughly 0.8 grams per kilogram of body weight, which is the minimum daily reference intake (DRI) for protein. It is recommended that active individuals consume 1.2 to 1.8 gram of protein per kilogram body weight. Active individuals on a hypocaloric diet are at a higher risk for developing a protein deficiency [6]. These actively training soldiers may not be getting an adequate amount of daily energy intake. They may need to increase their protein intake to at least 30 percent of their total caloric intake or roughly two grams of protein per kilogram body weight to maintain their FFM during periods of intense training [7, 8, 9, 10]. Also, soldiers voluntarily taking in low amounts of carbohydrates may experience decreased power output as their glycogen stores may be lower prior to training activities. Moreover, during periods of intense training, when glycogen stores can become depleted, protein oxidation can increase to allow for greater energy production and overall performance [11, 12]. The greater oxidation of dietary amino acids helps preserve skeletal muscle [13], allowing for greater performance during training sessions.

It has been shown that during prolonged exercise or multiple exercise bouts, it is most beneficial to combine a moderate-carbohydrate, high-protein meal or beverage post-workout to maintain muscle integrity and muscle glycogen stores [14, 15]. This indicates that soldiers actively participating in intense military training need to take in a moderate-carbohydrate, higher-protein meal after each workout. During a training program, soldiers are engaging in



physical activity during most of their waking hours. It may be beneficial for these soldiers to be taking in frequent meals to meet their nutrient needs. It has been shown that small frequent meals can help maintain FFM [16], and it has been suggested to improve subsequent performance by maintaining glycogen stores [14, 15]. Due to the aforementioned reasons, it was hypothesized that a higher-protein diet (HPD) with frequent meals would result in FFM maintenance and improved performance during intense military training.

## **Methods**

*Subjects:* This study consisted of 36 males who were  $21 \pm 1$  years of age and chose to participate in a summer Air Force Combatives training program. These subjects were chosen because of the high number of males participating in Air Force training programs and because these programs have cadets from all over the United States. Forty-two subjects were initially recruited for the study. However, injuries and statistical outliers led to 10 subjects being removed from the study (figure 1). The Kansas State University Institutional Review Board approved all methods and procedures used in the study.

*Design:* The study lasted 12 days and included 10 four-hour exercise sessions. Prior to the start of the 12-day training course, an initial consult occurred to thoroughly explain the research project and obtain informed consents. An initial nutritional counseling session also took place prior to the start of the training session, and nutritional counseling was available to all participants throughout the duration of the study. During the initial meeting, subjects were informed of acceptable food choices and given examples of acceptable daily food intakes and meals times. During the 12-day training period, all participants were assigned an isocaloric HPD. Based on preliminary data collection, the average age, height and weight of Air Force Combative participants was determined. The Harris Benedict equation was used to determine that

participants needed 3,289 calories daily to achieve an isocaloric diet, given the participants' estimated resting energy expenditure and intense level of physical activity (physical activity factor = 1.725).

The total caloric breakdown for the diet was designed to be 13,759 kJ with 40 percent carbohydrates (329 grams), 30 percent protein (247 grams) and 30 percent fats (110 grams). Participants were to remain on the prescribed diet during the 12-day training session, which consisted of Combatives practice five times per week for four hours at a time. This is a common workout protocol for this program.

Combatives practice was a supervised exercise period. Each session consisted of a 30-minute warm-up that included calisthenics, shrimping, umpa drills and other basic grappling techniques. The next 90 minutes was spent drilling technique. During this time, cadets would pair off and go through a series of positioning drills. The drills were designed in such a way that each technique would lead into another technique and each partner would have to perform the correct technique in order for the drill to flow continuously. There was a brief break, followed by another 90 minutes of live sparring. Sparring is similar to wrestling, except the participants are attempting to submit, rather than pin one another. A submission occurs when one person “taps out.” By physically tapping the mat or their opponent or by verbally tapping, one person has admitted defeat. A submission can occur due to a choke or joint lock that cannot be escaped.

Participants performed pre- and post-intervention testing that consisted of body weight measurement, body composition analysis, vertical jump and explosive leg power index (LPI) testing to assess explosive power and anaerobic capacity testing using a 600 meter shuttle run. Body weight was measured using a standard digital scale (Ohaus ES200L, Pine Brook, NJ). Body composition was analyzed using dual-energy X-ray absorptiometry (GE-Lunar Prodigy v

10.6, General Electric, Milwaukee, WI). The Just Jump System (Probotics, Huntsville, AL) was used to measure single vertical jump height and explosive leg power index. To determine LPI, participants performed a series of four jumps in rapid succession, attempting to jump as high and as fast as possible. Participants were given a five-minute break, and then they repeated the series of four jumps two more times. Anaerobic power was determined by performing a 600-meter shuttle run. The run was separated into two 300-meter shuttle runs with a five-minute rest between attempts. The time recorded for the 600-meter was the average of the two 300-meter attempts. Near completion of the training program, participants completed a 24-hour diet recall to assess dietary adherence. Nutritionist Pro diet analysis software was used for analysis of the diet records.

*Statistical Analysis:* Using SPSS, performance outliers were determined and removed using stem and leaf plots. Descriptive statistics were determined for all variables. Paired t-tests were used to determine significance of changes in the study. Pearson's Correlations were determined between dependent and independent variables.

## **Results**

There were no significant correlations between diet variables and anthropometric changes or performance changes, except a negative correlation between the change in average vertical jump height and percentage of total calories coming from dietary protein ( $r=-.447$ ,  $p<0.001$ ). There were significant changes in the pre-test and post-test measures, reported in table 1. Total body mass increased by  $0.6 \pm 1.1$  kg ( $p<.001$ ), while percent body fat decreased by  $1.1 \pm 0.9$  ( $p<.001$ ). FFM increased by  $1.3 \pm 1.1$  kg ( $p<.001$ ), while fat mass (FM) decreased by  $0.7 \pm 0.7$  ( $p<.001$ ). Averaged 600-meter shuttle times decreased by  $1.2 \pm 1.8$  seconds ( $p<.001$ ). The highest single vertical jump and average vertical jump height did not significantly change. The

peak LPI and average LPI increased by  $0.12 \pm 0.22$  ( $p < .001$ ) and  $0.13 \pm 0.22$  ( $p < .001$ ), respectively.

Dietary adherence is summarized in table 2. Observed total energy intake was  $14,110 \pm 4,389$  joules. The average observed macronutrient breakdown of the participants' diets was  $52 \pm 11$  percent carbohydrates ( $437 \pm 155$  g),  $19 \pm 4$  percent protein ( $157 \pm 65$  g) and  $32 \pm 9$  percent fat ( $119 \pm 53$  g). There were no correlations between meal frequency and anthropometric changes or performance changes. Meal frequency was reported to be 64 percent of the subjects consuming three meals and one to three snacks daily, 22 percent of the subjects consuming two meals and one to three snacks daily, and 13 percent of participants reported to consume two large meals and no snacks daily.

## **Discussion**

The purpose of this study was to examine the use of a HPD with frequent meals to cause greater lean tissue maintenance and improved performance during intense military training. This goal, however, was not reached and the primary explanation was the lack of dietary adherence. Test subjects failed to take in a HPD; however, most of the subjects did consumer two or three large meals and snacked throughout the day. This lack of adherence was not completely the subjects' fault. Study participants stayed in army barracks that had no refrigeration or food storage units, and their meal times were determined by the mess hall's hours of operation. Anecdotally, mess hall workers predetermined the food selection, and subjects were only allowed one trip through the food line and could not request additional servings of food.

On average, the participants gained FFM while losing FM. One plausible explanation for this is the frequency of meals. During the study, 70 percent of the subjects consumed three regular meals and one to three snacks throughout the day. Frequent food consumption can result

in retention of lean mass during periods of intense physical activity [16]. Iwao et al [1997] performed a study examining the impact of meal frequency on body composition in amateur boxers during a period of weight control. Participants in this study were divided into two groups, and each group was given the same calories. The difference was one group was given their calories in two meals, while the other group had their calories divided up among six meals. The individuals who only consumed two meals lost lean mass over the two-week weight control period, which was a similar time period as the present study. Therefore, the consumption of normal meals and frequent snacks seems to help maintain lean mass while exercising for prolonged periods of time. It is important to keep in mind that an increase in glycogen stores can result in a greater amount of body water, which would be identified in an increase in lean mass.

Exercise for this study was highly regulated and may explain some of the improvements in body composition. Layman et al [2005] performed a study comparing a higher-protein diet versus a higher-carbohydrate diet for weight loss. That study consisted of four groups; two groups were prescribed the higher-protein diet and two groups were prescribed the higher-carbohydrate diet. One group from each pair was also assigned an exercise regimen. It was found that the exercise regimen resulted in greater maintenance of FFM despite the diet. FFM constitutes a variety of tissue, including muscle tissue. By remaining physically active during weight loss, participants may have maintained the integrity of their muscle tissue, thus the retention of FFM.

The increase in FFM could have been, in part, caused by an increase in muscle tissue. An increase in local muscle concentrations could explain the improved sprint time results in the post-intervention performance testing. Sprinting requires explosive, powerful contractions of large muscle groups in the lower extremities. As muscle tissue increases, the potential contractile

power of these muscles would have also increased, causing a decrease in time to finish sprinting. It is interesting that the vertical jump height did not improve as FFM increased. A plausible explanation for the decrease in LPI during the vertical jump testing is that subjects were trying to jump more accurately on the Just Jump system. The Just Jump system requires that participants jump and land on a 27" x 27" mat for their attempt to be recorded. It was observed that during post-testing, subjects seemed to be focusing more on where they landed rather than jumping height.

The LPI was determined by jump height divided by ground contact time. The greater focus on landing location may have hindered jump height and caused longer ground contact time, resulting in a decreased power factor. It is unclear why there was a moderate ( $r=.45$ ) negative correlation between the change in vertical jump height and the percentage of dietary protein. It is possible that given the variability of the sample size, this was a false-positive correlation. More research is needed to determine an explanation for this correlation.

There are several limitations to the present study. One key limitation was the lack of dietary control during the study. Initially, it had seemed that participants would have been able to follow the dietary guidelines giving the cafeteria style dining area. It was not anticipated that participants would not be allowed additional serving of food at meal time. Had food limitations been known at the start of the study, attempts would have been made to provide food for the subjects to meet dietary guidelines set forth by the study. It would have been beneficial for the study if the subjects had had greater control over their food selection in their free living environment. Another limitation to this study is the unknown composition of the participants' diet prior to the start of the training session. There may have been some predisposing factors that affected both performance and diets during the study. Participants were on summer break at the

time and may have deviated from their normal diet and physical activity routine. Motivation of the subjects may have been a limitation as well. Anecdotally, the excitement to work hard decreased during the 12-day training session. This could have negatively affected post-testing procedures.

Despite the limitations of this study, the literature supports the use of HPD to benefit military personnel during intense training sessions by aiding in the maintenance of lean tissue that is needed to perform at optimal capacities. Lack of dietary adherence greatly affected the outcome of this study. Future studies would benefit from having greater control over the macronutrient breakdown of the diets soldiers consume during military training.

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## Figures & Tables

**Table 1. Pre-test and Post-test measurements**

Variables	Pre	Post	Change ( $\Delta$ )
Body Weight (kg)	78.4 + 6.8	79.0 + 6.8	0.6 + 1.1**
% Body Fat	19.9 + 6.0	18.8 + 5.6	-1.1 + 0.9**
FFM (kg)	59.8 + 4.3	61.2 + 4.7	1.3 + 1.1 **
FM (kg)	15.2 + 5.3	14.4 + 5.0	-0.7 + 0.7**
600m (seconds)	66.2 + 3.6	65.0 + 3.3	-1.2 + 1.8**
Highest Vertical (in)	61.4 + 8.8	61.5 + 9.0	-0.2 + 2.4
Avg Vertical (in)	59.3 + 8.3	59.6 + 8.6	0.0 + 2.0
Highest Leg Power Index	1.27 + 0.36	1.39 + 0.37	0.12 + 0.22**
Avg Leg Power Index	1.19 + 0.33	1.33 + 0.34	0.13 + 0.17**

\* statistically significant difference between pre- and post-test ( $p < 0.05$ )

\*\* statistically significant difference between pre- and post-test ( $p < 0.01$ )

**Table 2. Macronutrient distribution and total energy**

	Prescribed Values	Observed Values
Total Energy (kJ)	13,759 $\pm$ 0	14,110 $\pm$ 4,389
Carbohydrate (g)	329 $\pm$ 0	437 $\pm$ 155**
Carbohydrate (%)	40 $\pm$ 0	52 $\pm$ 11**
Protein (g)	247 $\pm$ 0	157 $\pm$ 65**
Protein (%)	30 $\pm$ 0	19 $\pm$ 4**
Fat (g)	110 $\pm$ 0	119 $\pm$ 53
Fat (%)	30 $\pm$ 0	32 $\pm$ 9

\*\*statistically significant difference from prescribed value ( $p < 0.01$ )



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## CHAPTER 3 - All Army Combatives Articles

### Use of Higher-Protein Diets for Body Composition Improvement in Non-Obese, Active Individuals. Case, JA, Haub, MD.

#### Abstract

**Background:** A significant amount of weight loss research has been performed on obese, overweight and/or sedentary individuals. There is little research available looking at the same weight loss techniques in athletes, even though this population is continually attempting to lose weight and/or alter body composition. **Hypothesis:** It is hypothesized that a higher-protein diet will result in greater weight loss and a decrease in percent body fat in lean individuals when compared to similar individuals on a low-fat, high-carbohydrate diet. **Design:** Subjects consisted of 30 males active in the military,  $25 \pm 4$  years old with  $15 \pm 7$  percent body fat. Participants took part in a six-week Military Combatives training camp that had supervised physical activity 10 hours each week. During the six-week training program, subjects were prescribed one of three diets: higher-protein (PRO), traditional low-fat, high-carbohydrate (CHO), or control. The PRO diet was designed to be 40% carbohydrates, 30% protein and 30% fats. The CHO diet was designed to be 65% carbohydrates, 15% protein and 20% fats. The control group participated in all physical activity but was not given any dietary restrictions. **Results:** Thirteen subjects completed the study. Control group consumed  $16,489 \pm 4,823$  kJ daily consisting of  $41 \pm 10\%$  carbohydrates,  $23 \pm 2\%$  protein and  $33 \pm 9\%$  fats. PRO group consumed  $8,339 \pm 2,173$  kJ consisting of  $36 \pm 10\%$  carbohydrates,  $30 \pm 10\%$  protein and  $35 \pm 8\%$  fat. CHO group consumed  $14,536 \pm 6,879$  kJ consisting of  $58 \pm 10\%$  carbohydrates,  $17 \pm 2\%$  protein and  $26 \pm 10\%$  fat. Control group consumed  $224 \pm 62$  kJ/kg body weight with  $5 \pm 1$  g carbohydrates/kg body weight,

$3 \pm 1$  g protein/kg body weight, and  $2 \pm 1$  g fat/kg body weight. PRO group consumed  $120 \pm 50$  kJ/kg body weight with  $3 \pm 2$  g carbohydrates/kg body weight,  $2 \pm 1$  g protein/kg body weight and  $1 \pm 0$  g fat/kg body weight. CHO group consumed  $213 \pm 122$  kJ/kg body weight with  $7 \pm 3$  g carbohydrates/kg body weight,  $2 \pm 1$  g protein/kg body weight and  $2 \pm 1$  g fat/kg body weight. Body weight changes were as follows: CHO group loss  $1.1 \pm 5.2$  kg, PRO group loss  $0.2 \pm 2.2$  kg, and control group gained  $1.0 \pm 1.0$  kg. PRO group had the greatest decrease in percent body fat, followed by CHO group and then control group with  $-1.2 \pm 0.8$  kg,  $-1.1 \pm 0.9$  kg and  $-0.6 \pm 1.5$  kg, respectively. Control and PRO group increased FFM,  $1.7 \pm 1.2$  kg and  $0.8 \pm 1.5$  kg, respectively. CHO group lost  $-0.2 \pm 3.8$  kg FFM. PRO and CHO groups lost  $1.0 \pm 1.0$  kg and  $1.0 \pm 1.8$  kg of FM, respectively. Control group lost  $0.7 \pm 0.7$  kg FM. **Conclusion:** It appears that a higher-protein diet can improve FFM retention during weight loss in non-obese, active individuals.

## Introduction

Most studies on weight loss and changes to body composition have investigated the effects in obese, overweight or sedentary individuals, but there is an entire population of active, non-obese individuals who want to lose weight and/or change their body composition. One exception is a study done by Zachwieja et al [1] that consisted of participants in the optimal range for Body Mass Index (BMI). Researchers in this study were examining the use of caloric restriction to cause weight loss in non-overweight individuals. An interesting finding of this study was that the participants lost weight while under energy restriction, but not to the same extent that has been seen in their overweight and obese counterparts. This begs the question whether current weight loss methods studied in overweight and obese individuals would be as

effective for non-overweight individuals who would not be recommended to lose weight for health issues.

There are a variety of diets marketed for weight loss. The main difference between each of these diets is the macronutrient composition and/or the total caloric allotment. There are three basic classifications for these diets: high-protein, moderate fat, low-fat and high carbohydrate. Common high-protein diets are the South Beach ® diet, Atkins ® diet and Zone ® diet. The range of protein intake for these diets is typically 30 to 35 percent of total daily calories. The key difference between these three diets is fat intake. The Atkins® diet allows for a high amount of fat, as much as 60 percent of total calories, while the other diets limit fat intake to 30 to 40 percent of total caloric intake [2]. Another diet that is liberal with fat intake is the Mediterranean diet, which is classified as a moderate fat diet and emphasizes monounsaturated and polyunsaturated fat intake. The final classification of popular weight loss diets is the low-fat, high-carbohydrate diet, such as the Weight Watchers ® program and the Ornish diet. The striking difference between these diets is the restrictiveness of the Ornish diet, compared to Weight Watchers® allowances for indulgences on sweets and fats on occasionally [3].

All of the aforementioned diets can cause weight loss to a certain degree, although it appears that the high-protein diet causes the greatest amount of fat-mass (FM) loss [4, 5, 6], which is typically the goal of any weight loss program. Compared with other diets, high-protein diets also have been shown to enhance weight loss by increasing thermogenesis and satiety and reducing subsequent food intake [4, 7, 8, 9, 10]. Besides the changes to body composition, higher-protein diets have been shown to improve insulin sensitivity and blood lipid profiles [5,6]. Another benefit of a higher-protein diet, in comparison to other diets, is greater dietary

adherence [11, 12] and a lower rate of weight regain following termination of the diet program [13].

It is important to keep in mind that higher-protein diets help maintain fat-free mass (FFM) [5], which includes lean mass or muscle mass. For active individuals, the retention of muscle mass is very important for exercise performance. Regardless of the type of exercise being performed, loss of lean tissue can result in a decrease in overall performance. Traditional dietary recommendations for weight loss are 60 percent or more calories from carbohydrates, 15 percent from protein and 20 percent or less from fat [14]. Such a low contribution of dietary protein could cause an athlete to lose lean mass, which can result in a decrease in athletic performance despite training measures. It is hypothesized that a higher-protein diet will result in greater weight loss and improved body composition in lean individuals when compared to the traditional low-fat, high-carbohydrate diet, which consists of less than 20 percent of total calories from fats and more than 60 percent of total calories from carbohydrates.

## **Methods**

*Subjects:* This study consisted of 30 males who were  $25 \pm 4$  years old with  $15 \pm 7$  percent body fat. Study participants were actively participating and competing for a spot on the Army Combatives competition team. These subjects were chosen because of the high number of males participating in Combatives training. Army Combatives consists of ju-jitsu, Pankration and mixed martial arts fighting. Competitors are divided into weight classes. There was a higher than expected rate of dropout in this study due to the competitive nature of the Combatives program. Some participants did not make the team and chose to leave the study, and others left due to injuries. Additionally, because all participants were active military personnel, some had job conflicts that prevented them from participating in the study (figure 1). All methods and

procedures done in this study were approved by the Kansas State University Institutional Review Board.

*Design:* This study lasted six weeks, with 10 hours of exercise occurring each week. Prior to the start of the six-week training course, an initial consultation occurred to thoroughly explain the research project and obtain informed consents. An initial nutritional counseling session also took place prior to the start of the training program. Nutritional counseling was available to all participants throughout the duration of the study. During the initial meeting, subjects were informed of acceptable food choices and given examples of acceptable daily food intakes. Handouts were provided that listed the number of servings allotted per food group along with explanation of serving sizes. Participants were also given two sample menus to further explain the prescribed diet. During the six week training period, participants were assigned to the higher-protein (PRO) group, traditional low-fat, high-carbohydrate (CHO) group or control group. The total caloric breakdown for the PRO diet was designed to be 40 percent of total calories from carbohydrates, 30 percent from protein and 30 percent from fat. The CHO diet was designed to have 65 percent of the total calories from carbohydrates, 15 percent from protein and 20 percent from fat. Subjects in the control group participated in all physical activity but were not given any dietary restrictions or guidelines.

Participants were to remain on their prescribed diets while participating in Combatives practice five times per week for two hours each time, which is a common workout protocol for this program. Each practice session included calisthenics, technique drills and sparring/fighting rounds. Each exercise session would begin with a 30-minute warm-up consisting of bear crawls, burpees, sprawls, break-falls, hip-ups and other various movements to get the fighters' body for the full-body workout that was about to begin. After the warm-up, fighters move into the

technique portion of class. This period can last up to an hour. During this period of fighters will take part in drills that can help hone their fighting techniques. These drills are very explosive and nonstop. They are designed in such a way that one technique flows into another technique, thus the fighters never stop moving during this time. The remaining class time is used for live sparring. Due to the dynamic nature of Army Combatives, this time could be used for wrestling takedown/judo, submission wrestling, Pankration, boxing, kickboxing or MMA fighting. During this time the fighters completed multiple five-minute rounds with a one-minute rest between rounds.

Participants performed pre- and post-intervention testing that consisted of body weight measurement using a digital scale and body composition analysis using Dual-Energy X-ray Absorptiometry (GE-Lunar Prodigy v 10.6, General Electric, Milwaukee, WI). During the final week of the program, a 24 or 72 hour diet record was kept and analyzed using Nutritionist Pro diet analysis software.

*Statistical Analysis:* Using SPSS analytical software, descriptive statistics were determined for all variables. Paired t-tests were used to determine significance of changes in the study. Pearson's Correlations were determined between dependent and independent variables. One-way ANOVA was used to determine differences between groups.

## **Results**

*Subjects:* Due to the high dropout rate, the final groups consisted of five subjects in the control group and four subjects in each of the dieting groups. Each group differed slightly in initial characteristics; however, none of the differences reached a level of statistical significance.

*Diet Adherence:* Figure 3 summarizes the observed diets and prescribed diets for each group. The control group consumed  $16,489 \pm 4,823$  kJ daily with  $41 \pm 10$  percent of the total



energy from carbohydrates,  $23 \pm 2$  percent from protein and  $33 \pm 9$  percent from fat. The PRO group was set to have a macronutrient breakdown of 40 percent carbohydrates, 30 percent protein and 30 percent fat. Subjects in the PRO group actually consumed  $8,339 \pm 2,173$  kJ, with a macronutrient breakdown of  $36 \pm 10$  percent carbohydrates,  $30 \pm 10$  percent protein and  $35 \pm 8$  percent fat. The CHO group was prescribed a low-fat, high-carbohydrate diet consisting of 65 percent carbohydrates, 15 percent protein and 20 percent fat. The observed diets of this group consisted of  $14,536 \pm 6,879$  kJ, with  $58 \pm 10$  percent carbohydrates,  $17 \pm 2$  percent protein and  $26 \pm 10$  percent fat.

Due to the distinct difference in total energy intake between groups, dietary intake was further analyzed to examine nutrient intake per kilogram of body weight. These results are summarized in figure 4. The control group consumed  $224 \pm 62$  kJ/kg body weight, with an average consumption of  $5 \pm 1$  grams of carbohydrates per kilogram body weight,  $3 \pm 1$  grams of protein per kilogram body weight and  $2 \pm 1$  grams of fat per kilogram body weight. The PRO group consumed  $120 \pm 50$  kJ/kg body weight with  $3 \pm 2$  grams of carbohydrates per kilogram body weight,  $2 \pm 1$  grams of protein per kilogram body weight and  $1 \pm 0$  gram of fat per kilogram body weight. The CHO group consumed an average of  $213 \pm 122$  kJ/kg body weight,  $7 \pm 3$  grams of carbohydrates per kilogram body weight,  $2 \pm 1$  grams of protein per kilogram body weight and  $2 \pm 1$  gram of fat per kilogram body weight.

*Anthropometric Measures:* Due to the small sample size, there were no statistically significant differences between groups; however, there are some trends available. These results are summarized in chart 1 and graph 1. The greatest amount of weight loss was seen in the CHO group with an average weight loss of  $1.1 \pm 5.2$  kg. PRO group had an average weight loss of  $0.2 \pm 2.2$  kg, while the control group gained an average of  $1.0 \pm 1.0$  kg. All groups had a decrease in

percent body fat. PRO group had the greatest decrease, followed by CHO group and control group with a decrease of  $-1.2 \pm 0.8$  kg,  $-1.1 \pm 0.9$  kg and  $-0.6 \pm 1.5$  kg, respectively. Both the control and PRO group had an increase in FFM by  $1.7 \pm 1.2$  kg and  $0.8 \pm 1.5$  kg, respectively, while the CHO group lost  $-0.2 \pm 3.8$  kg. The amount of FFM gain by the control group was statistically significant ( $p < 0.05$ ). All groups had a decrease in FM. The PRO and CHO groups had a similar amount of FM loss with  $1.0 \pm 1.0$  kg and  $1.0 \pm 1.8$  kg, respectively. The control group lost the least amount of FM with  $0.7 \pm 0.7$  kg.

## Discussion

This study was designed to determine whether a higher-protein diet would result in greater weight loss and body composition changes when compared to a traditional low-fat, high-carbohydrate diet. Despite the small sample size in this study, there are promising results. In terms of total weight loss, the CHO group lost the most amount of weight, and a large portion of that weight loss was FFM. It was anticipated that the CHO group would lose FFM; however, it was not anticipated that they would have the greatest amount of weight loss. Given the available literature, the PRO group was expected to have the greatest weight loss. The PRO group did, as expected, have an increase in FFM.

Given the reported energy intakes, the PRO group was the only group with an energy deficit. The control group, on average, was taking in 3680 kJ more than was required to maintain their current weight and exercise level. Thus, it is understandable that the control group gained weight during the training program. The CHO group reported an average consumption of  $14.54 \pm 6.9$  MJ, which was about 1240 kJ more than was required to maintain their current weight and exercise level. Given their reported intake, the observed weight loss should not have occurred. The PRO group had an energy deficit of about 4550 kJ, which should have resulted in a loss of

about 6 kg body weight. However, that amount of weight loss was not seen. It is possible that there were some errors in the self-reported diet records.

Another explanation for the lower than expected amount of weight loss is the attitude of the coaches supervising the Combatives program. The coaches had the traditional ideology that “cutting weight” via dehydration and exercise in a hot environment 24-hours prior to the event was acceptable. Their attitudes may have impacted the subjects’ desire to follow the prescribed diet.

These findings are supported by research done by Layman et al (2005) where participants were divided into two hypocaloric diet groups: a high-carbohydrate diet (55 percent carbohydrates, 15 percent protein and 30 percent fat) and a higher-protein diet (40 percent carbohydrates, 30 percent protein and 30 percent fat). In addition, these groups were further split into exercising and non-exercising groups, which equaled four different study groups with 12 subjects per group. The results of this study showed that all four groups lost weight due to the hypocaloric nature of their diets. In terms of body composition changes, the two protein groups resisted FFM loss while both carbohydrate groups lost FFM. In fact, the group that just followed the high-carbohydrate diet (non-exercising) lost significantly more FFM than the high-carbohydrate plus exercise group. Overall, regardless of diet treatment, exercise helped decrease the extent of FFM loss. These results help support the findings and hypothesis of the current study by showing that a higher-protein diet can help improve body composition during periods of weight loss.

Patti et al [6] also had similar findings in groups of obese females. Their study lasted 21 days and consisted of two diets: a high-carbohydrate diet (60 percent carbohydrates, 20 percent protein and 20 percent fat) and a higher-protein diet (35 percent carbohydrates, 45 percent

protein and 20 percent fat). The weight loss between the two groups was similar; however, the body composition changes were very different. The carbohydrate group lost significantly more FFM, while the protein group maintained FFM and lost significant amounts of fat mass. Again, this supports the idea that during periods of weight loss, a higher amount of protein intake is needed to maintain FFM. In fact, multiple researchers have found that during periods of weight loss, a higher-protein diet with a minimum of 100 grams of protein or 30 percent of total calories from protein is required to maintain lean mass [15, 16, 17, 18].

Another interesting finding from this current study was the drastic difference in total energy intake between the PRO group and the other groups. The control group was not given any dietary instructions, and the CHO and PRO groups were prescribed similar amounts of energy. A primary explanation for why the PRO group voluntarily took in significantly less energy is because of the satiation effects that occur when on a higher-protein diet [4, 7, 8, 9, 10, 11, 13]. It is possible that low caloric intake was the result of improper self-reporting on the diet records.

A previous study found that even in free-feeding environments, a higher-protein diet results in a spontaneous decrease of subsequent energy intake. Latner et al [7] examined the second meal effect when consuming a high-protein meal, consisting of 9.5 percent carbohydrates, 71.5 percent protein and 19 percent fat, versus a high-carbohydrate meal consisting of 99 percent carbohydrates and 0 percent fat and protein. Participants were given a liquid lunch consisting of the aforementioned macronutrient breakdown, and then they were given a four and a half-hour break before being served a buffet-style dinner. Participants in the high-protein group reported a greater rating of satiety following the liquid lunch when compared with the high-carbohydrate group. The study found that the high-carbohydrate group consumed an average of 300 more calories and greater amounts of carbohydrates and fats during the dinner

meal than the high-protein group. The greater intake of calories and nutrients in the carbohydrate group is thought to be associated with the lower levels of satiety that occur after consumption of the liquid lunch.

A possible explanation for the increase in satiety after consuming higher-protein meals has to do with the increased level of thermogenesis [4, 9, 10, 11]. Higher-protein diets have been shown to increase thermogenesis because of the increased thermic affect of food when consuming dietary protein. The thermic affect of food is the amount of energy required during digestion, absorption and metabolism of nutrients. In terms of energy expenditure, protein digestion is very costly. About 30 percent of the energy derived from protein is used during digestion, absorption and metabolism [10]. The metabolism of carbohydrates and fat is much more efficient; the thermic affect of carbohydrate digestion and absorption is only 4 to 8 percent of its total energy intake, and fat only has a thermic affect of about 1 to 2 percent [10]. It is thought that this increase in thermogenesis seen during higher-protein consumption can result in greater satiety and result in decreased energy intake, such as in this current study.

There was an interesting post-hoc assessment. One test subject closely followed the traditional low-fat, high-carbohydrate diet recommendations. This subject's diet consisted of 72.3 percent carbohydrates, 18.3 percent protein and 12.0 percent fat. The subject also had the greatest amount of weight loss with a loss of 8.5 kilograms during the six-week study period. Unfortunately, 5.8 kilograms were FFM loss, while only 3.1 kilograms were FM loss. Also, this test subject had an initial BMI of 31 which placed him in the obese category, while the rest of the participants were classified as overweight or normal. Because of his BMI rating and high amount of weight loss compared to the other subjects, statistics were redone without this subject's data.

When looking at all the anthropometric changes with the aforementioned subject removed, the remaining CHO (CHO2) group actually gained  $1.4 \pm 1.9$  kilograms. The percent body fat of the CHO2 group decreased because there was a gain of  $1.7 \pm 0.7$ kg FFM and a loss of  $0.3 \pm 1.3$ kg FM. Figure 7 compares the changes in body composition of the CHO2 group to the other study groups. The unexpected changes in body composition resulted in further analysis of dietary intakes. When the diets of the CHO2 group were compared to dietary guidelines for the PRO group, it was found that CHO2 group almost consumed the prescribed higher-protein diet. The main difference is that in terms of absolute values, the CHO2 group consumed more carbohydrates than was recommended for the higher-protein diet. The recommended amount of carbohydrates for the higher-protein diet was  $270 \pm 0$  grams, and the CHO2 group was consuming  $565.1 \pm 94.3$  grams.

Not only did the CHO2 group consume a high amount of carbohydrates, but they also consumed a high amount of energy. The group consumed an average of  $17,686 + 3,371$  kJ or  $268 + 64$  kJ/kg body weight. This is much greater than the recommended  $11,072 + 936$  kJ or  $164 + 12$  kJ/kg body weight. When looking at the percentage of total calories from protein, the CHO2 group was not meeting the higher-protein diet requirements. However, when evaluating the absolute gram amounts, the CHO2 group consumed an adequate amount of dietary protein to meet the prescribed values for a higher-protein diet. The higher-protein diet guideline is  $3.0 \pm 0.1$  grams of protein per kilogram body weight, and the CHO2 group consumed  $2.7 \pm 1.0$  grams of protein per kilogram body weight. The CHO2 group was actually consuming a higher-protein high-energy diet, which may explain why its participants had such an increase in FFM.

There are some limitations to this current study. The foremost was the small sample size. It would be advantageous for future research to be done on this area using a larger sample size.

The unexpected high rate of dropout was also a limitation in this study. In prior studies conducted by this research team, dropout rates were between 5 to 15 percent. However, given the demanding schedule of military personnel, a higher dropout rate is unavoidable. A final limitation of this study was the lack of dietary adherence. There were some issues regarding proper record keeping and reporting of serving sizes. It would have been more beneficial for statistical analysis if each group consumed the same amount of calories and the prescribed macronutrient intake, but the subjects were in a free-living environment and were allowed to choose their own food.

In conclusion, the statistical trends presented in this study indicate that there are possible benefits of using a higher-protein diet during weight loss in lean individuals; such a diet may improve body composition by maintaining FFM and reducing FM. A higher-carbohydrate diet can result in weight loss; however, much of that weight loss appears to be the result of FFM loss, which can negatively impact the performance of active individuals. Future research is needed in this area to determine the magnitude of FM that is lost by lean individuals consuming a higher-protein diet. The current study did have some limitations, particularly the small sample size. Despite that, the study's concept is still valid. Future studies need to be done in this area with greater control over subject size and nutrient intake; this could result in more statistically significant differences. There is a large population of non-obese, active individuals using various weight loss techniques that have not been researched for their population. The group needs to be noticed and researched by the scientific community.

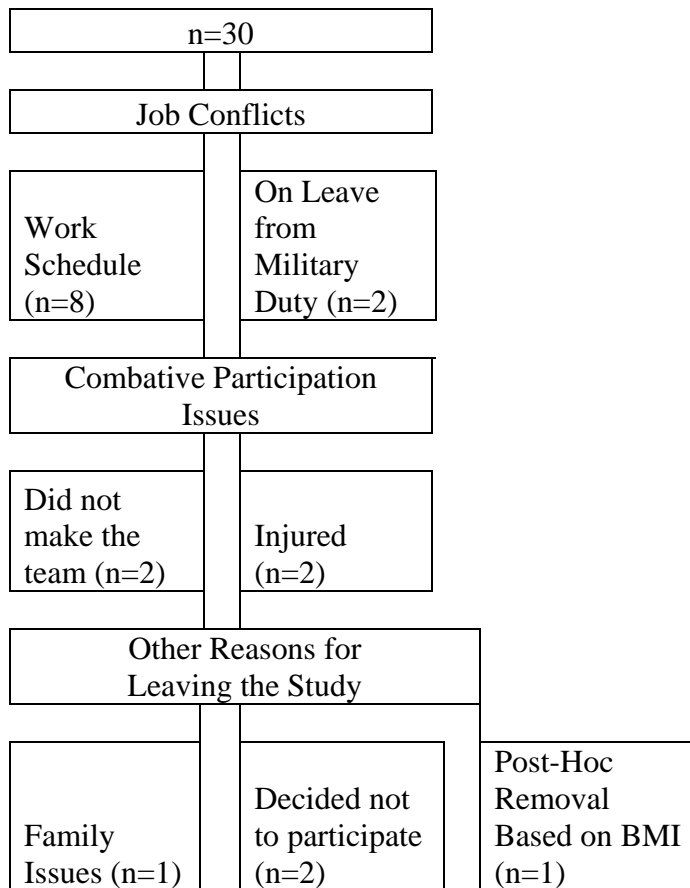
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## Tables & Figures

**Figure 1. Dropout rates and reasonings**



**Table 1. Initial Group Differences**

Group	Age (yrs)	Height (cm)	Weight (kg)	% Body Fat
Control	27 ± 6	173 ± 5	75 ± 11	14 ± 6
PRO	25 ± 3	178 ± 8	73 ± 11	15 ± 7
CHO	22 ± 2	177 ± 2	76 ± 20	14 ± 10
CHO2	21 ± 2	178 ± 3	67 ± 8	10 ± 1

**Table 2. Prescribed percentage of total energy vs. observed values**

Group	CHO (%) (Rx)	CHO (%) (obs)	PRO (%) (Rx)	PRO (%) (obs)	Fat (%) (Rx)	Fat (%) (obs)
Control	none	41 ± 10	none	23 ± 2	none	33 ± 9
PRO	40 ± 0	36 ± 10	30 ± 0	30 ± 6	30 ± 0	35 ± 8
CHO	65 ± 0	58 ± 10	15 ± 0	17 ± 2	20 ± 0	26 ± 10
CHO2	65 ± 0	54 ± 6	15 ± 0	17 ± 2	20 ± 0	31 ± 3

**Table 3. Prescribed energy intake vs. observed energy intake (bw = body weight)**

Group	Total Energy (kJ) (Rx)	Total Energy (kJ) (obs)	Total Energy (kJ/kg bw) (Rx)	Total Energy (kJ/kg bw) (obs)
Control	none	16,489 ± 4,823	none	224 ± 62
PRO	10,969 ± 791	8,339 ± 2,173	165 ± 10	119 ± 50
CHO	11,632 ± 1355	14,536 ± 6,876	158 ± 14	213 ± 122
CHO2	11,072 ± 936	17,686 ± 3,371	164 ± 12	268 ± 64

**Table 4. Prescribed values (g/kg body weight) vs. observed values**

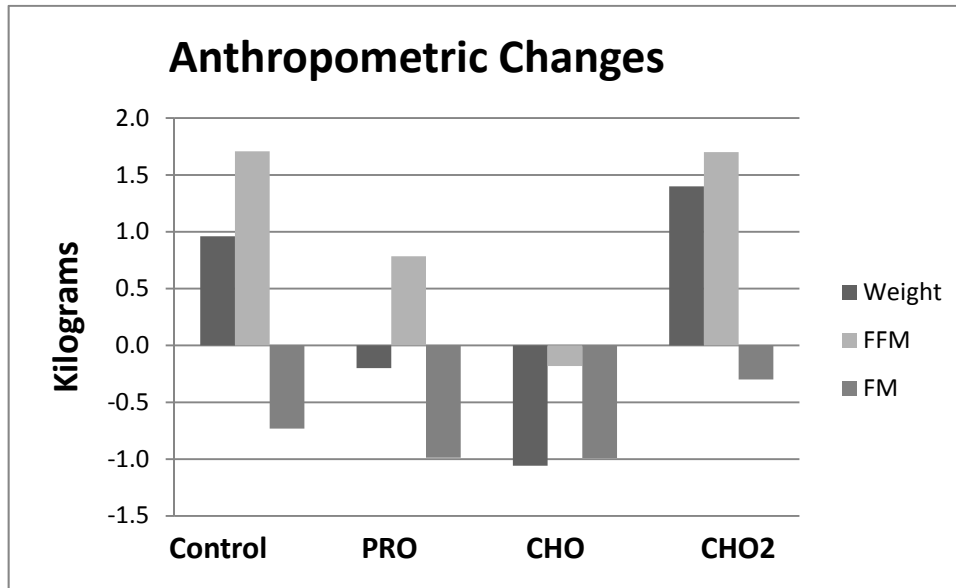
	CHO (g/kg) (Rx)	CHO (g/kg) (obs)	PRO (g/kg) (Rx)	PRO (g/kg) (obs)	Fat (g/kg) (Rx)	Fat (g/kg) (obs)
Control	none	5.3 ± 1.5	none	3.1 ± 0.8	none	2.1 ± 1.0
PRO	4.0 ± 0.2	2.8 ± 2.0	3.0 ± 0.2	2.1 ± 0.5	1.3 ± 0.1	1.1 ± 0.3
CHO	6.2 ± 0.6	6.9 ± 3.4	1.4 ± 0.1	2.2 ± 1.4	0.8 ± 0.1	1.7 ± 1.2
CHO2	6.4 ± 0.5	8.5 ± 1.5	1.5 ± 0.1	2.7 ± 1.0	0.9 ± 0.1	2.2 ± 0.7

**Table 5. Anthropometric changes**

Group	Weight (kg)	% Body Weight	Body Fat (%)	FFM (kg)	FM (kg)
Control	1.0 ± 1.0	1.26 ± 1.49	-1.1 ± 0.9	1.7 ± 1.2*	-0.7 ± 0.7
PRO	-0.2 ± 2.2	-0.3 ± 3.0	-1.2 ± 0.8	0.8 ± 1.5	-1 ± 1
CHO	-1.1 ± 5.2	-0.47 ± 5.6	-0.6 ± 1.5	-0.2 ± 3.8	-1 ± 1.8
CHO2	1.4 ± 1.9	2.06 ± 2.96	-0.7 ± 1.9	1.7 ± 0.7	0.3 ± 1.3

\*statistically significant change from pre-test to post-test (p<0.05)

**Figure 2. Comparison of anthropometric changes between groups**



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## Higher-Protein Diets Do Not Hinder Athletic Perform in Male Fighters.

Case, JA, Haub, MD.

### Abstract

**Background:** As Mixed Martial Arts grows in popularity, more athletes are participating in “weight cutting” to compete in weight classes that are below their regular weight. Current weight cutting techniques include dehydration, food restriction, diuretic use and self-induced vomiting to rapidly decrease weight. All of these can inhibit performance and negatively impact the health of an athlete. **Hypothesis:** It was hypothesized that the use of a higher protein diet could be used to replace current weight cutting practices resulting in safer measures for the athlete without hindering athletic performance in male fighters. **Design:** US Army soldiers (n=13, age=24±4yr, weight=75±13kg, body fat=14±7%) in the Combatives training program were recruited for this study. Prior to the start of the 6-week training program participants were prescribed one of three diets: PRO (40% carbohydrate, 30% protein, 30% fat), CHO (65% carbohydrate, 15% protein, 20% fat) and control (no dietary restrictions). Pre-test and post-test assessments of explosive power via vertical jump height and explosive leg power index (LPI), and anaerobic capacity via 600m shuttle and aerobic capacity via 1.5 mile run were completed during the first and last week of the 6-week program. **Results:** Control group consumed 16.49±4.8 MJ daily, 41±10% carbohydrates, 23±2% protein and 33±9% fat. PRO consumed 8.34±2.2 MJ, 36±10% carbohydrates, 30±10% protein and 35±8% fat. CHO group consumed 14.54± 6.9 MJ, 58±10% carbohydrates, 17±2% protein and 26±10% fat. Control group significantly decreased their 1.5 mile time, significantly increased highest power factor and significantly increased VO<sub>2</sub>max. There were no significant differences in the changes in performance variables between groups, except for the LPI. The CHO had a significantly different

change in the average power factor and highest power factor compared to the control group, but not compared to the PRO group. **Conclusion:** Higher-protein diets do not appear to hinder athletic performance in male fighters.

## **Introduction**

In the early '90s, a new sport took the nation by storm; Ultimate Fighting or what is now called Mixed Martial Arts (MMA), which encompasses boxing, kickboxing, wrestling, grappling and ju jitsu. MMA had been practiced in other countries for some time, but it was not until the UFC® brought it to the United States that it grabbed hold of American audiences. Since its first showing in the early 1990s, MMA events and organizations have sprung up all over the United States. With the rise in competition of the sport, there is a new problem. Many athletes competing in MMA or similar events, such as wrestling, practice rapid weight loss or “weight cutting” in order to participate in specific weight classes. Much like wrestling, these sports use defined weight classes to level the playing field so that larger competitors do not have an unfair advantage. In many sports using weight classifications, weight cutting is an inevitable and expected part of competition [1, 2]. Currently, there is a paucity of research examining combative sports like MMA, kickboxing, ju jitsu and grappling. There is, however, research available on wrestlers; while they have different competition schedules, these athletes use similar weight cutting practices, which is why it is relevant to look at research done on wrestlers.

A striking difference between wrestlers and MMA fighters is the amount of weight being cut and the frequency of the weight cutting. In a typical wrestling season, a wrestler will cut weight 10 to 14, times and each cut occurs about the same time each week [3]. It is not uncommon for wrestlers at all levels of competition to use weight cutting practices to lose eight to 20 kilograms during the 36 hours prior to an event [4, 5, 6, 7]. MMA fighters cut weight as

little as once a year to as often as 10 times a year. There is no defined MMA season as competitions occur throughout the year. Competitors may be given a few months notice before a fight or they may only be given 24 hours notice. The amount of weight cut varies between athletes, but fighter interviews have revealed cuts as large as 15 kilograms in a 24-hour period. The methods of weight loss used by these athletes have been self-reported to be similar to weight cutting methods used by wrestlers.

Studies done on adolescent, high school and college wrestlers found that many of the athletes and coaches, even those at elite levels of competition, tend to not have the nutritional knowledge required to safely decrease weight at an accelerated rate [8, 9, 10]. Current weight cutting practices include the use of dehydration, food restriction and exercise in hot environments, such as a in steam room or a sauna suit [11, 12]. In extreme cases, some athletes will resort to the use of laxatives, diuretics and self-induced vomiting in order to make weight for their competition [11, 12]. All of these methods not only have a negative impact on the performance [4, 5, 7, 12, 13, 14, 15, 16], they can also be very detrimental to the athletes health [11, 17].

Rapid weight loss typically results in loss of lean mass rather than fat mass [2, 6, 18], meaning that the athletes may be losing muscle mass needed for optimal performance. The rapid weight loss may also be due to water loss, which could result in a fluid imbalance that may hinder performance. This type of rapid weight loss often results in a rapid weight regain, which leads to weight cycling [1, 2, 3, 4, 5, 7, 8, 10, 13, 14, 16, 17, 19]. This act of weight cycling can occur up to 14 times during a normal competition season for wrestlers [3]. This is problematic for the athlete's health because each time the athlete regains the weight, they may be gaining more than they lost, making the next cut even more extreme. Weight cycling not only impacts



the athlete at the time of the cut, but later in life the athlete is at a greater risk for obesity and disordered eating [10, 20]. Moreover, most of the weight regained is located in the torso/abdominal region of the body, resulting in a higher accumulation of visceral fat and increasing the risk for cardiovascular disease as they age [3, 20].

To prevent detriments to health and performance due to weight loss, more research on this population is needed. There are studies on non-athletes that illustrate higher-protein intakes may be a means to safely decrease weight with potentially better long-term health outcomes. The purpose of this study is to look at the impact of the Zone® diets on athletic performance. The Zone diet consists of 30 percent protein, 40 percent carbohydrates and 30 percent fat [21, 22]. This type of diet has been repeatedly shown to elicit greater weight loss than the traditional low-fat diet [23, 24, 25, 26]. Higher-protein diets tend to maintain fat-free mass (FFM) during weight loss, while traditional low-fat diets often result in loss of relatively more FFM [27, 28, 29, 30]. Maintenance of FFM or muscle mass will likely result in greater strength and power over one's opponent and ultimately result in optimal athletic performance.

Currently there is limited research looking at the impact of higher-protein diets on performance. There is research available looking at low-carbohydrate diet and performance, but most of these diets are high in fat rather than high in protein [31, 32, 33]. Some studies have been done specifically examining the Zone diet and athletic performance, but the results are mixed. Jarvis et al [34] found that the Zone diet did not have a negative effect on athletic performance of recreational athletes. While Chevront et al [35] reported that the Zone diet had a negative impact on endurance athletes, it did not affect anaerobic performance, which is the type of exercise performed during an MMA event or a grappling tournament. Both of these studies support using a Zone-type diet to lose weight at an accelerated rate for athletes in power and

explosive sports. It is hypothesized that the use of a higher-protein diet could be used to replace current weight cutting practices and would not hinder athletic performance in male fighters.

## **Methods**

*Subjects:* 30 United States Army soldiers were recruited to participate in this study prior to beginning the intensive Combatives training program. Combatives combines grappling, Pankration (similar to kickboxing, but with limited ground fighting) and MMA fighting. Prior to the start of the six-week training program, an initial consult occurred to thoroughly explain the research project and obtain informed consents. All methods and procedures done in this study were approved by the Kansas State University Institutional Review Board.

Participants in this study were competing for a spot on the Army Combatives team and also were active military personnel. Due to these two factors, there was a high dropout rate. Some participants were unable to complete the study due to job conflicts, such as work schedules (n=8) or being on leave from military duty (n=2). Other participants did not make the team (n=2) or were injured (n=2). There were also some individuals who chose to leave the study for personal reasons such as having family obligations (n=1) or just deciding not to participate (n=2). There were 13 total subjects who completed the entire study (Table 1).

*Procedures:* Prior to the start of the six-week training program, subjects participated in an initial nutritional counseling session. During this session, subjects were assigned to a diet group: higher protein diet (PRO), low-fat, high-carbohydrate diet (CHO), or ad libitum (Control). Standard menus were individualized to meet micronutrient requirements for the prescribed diets, which were based on the subjects' anthropometric measures and exercise program using the Harris-Benedict equation and activity factors. Subjects had access to nutritional counseling throughout the six-week training period. During the last week of the training program, a 24 or 72

hour diet record was collected to evaluate dietary adherence. Nutritionist Pro, Version 4.3.0, diet analysis software was used to analyze the diet records.

During the six-week training period, participants were assigned to particular hypocaloric diets: PRO, CHO or control. The total caloric breakdown for the PRO diet was designed to be 40 percent carbohydrates, 30 percent protein and 30 percent fats. The CHO diet was designed to have 65 percent carbohydrates, 15 percent protein and 20 percent fats. Participants in the control group participated in all physical activities but were not given any dietary restrictions or guidelines.

*Assessments:* Assessments were taken after the third day of training to allow for the participants to learn and adapt to the exercise program. Subjects arrived to the lab after a three hour fast. Vertical jump heights were recorded using the Just Jump system (Probotics, Huntsville, AL) to assess explosive power. For this test, each participant completed three single vertical jumps with three-minutes of rest between jumps. Then participants completed three series of four vertical jumps in rapid succession to measure their explosive leg power index (LPI), which was done in triplicate. The LPI was determined based on the average time spent in the air divided by the average time spent on the jumping surface between each jump. This test was also used to assess explosive power. There was a three-minute break between each series. The following day, subjects arrived at an outdoor track to complete the aerobic and anaerobic tests. Subject performed a self-paced warm-up consisting of jogging and stretching. When ready, participants performed two 300 meter shuttle runs with a five minute break between attempts, as per the NSCA guidelines for the 600m shuttle run [36]. The anaerobic fitness was estimated based on the average time to complete both shuttle runs. After a 30-minute rest period, subjects completed a 1.5-mile run on an outdoor track to measure aerobic capacity. The test of the 1.5-

mile run was used because it is a common protocol for testing aerobic fitness in military personnel. The following equation was used to estimate VO<sub>2</sub>max values:  $VO_{2max} = 88.02 - .1656 (\text{body weight in kg}) - 2.76 (\text{time in minutes}) + 3.716 (\text{gender (males =1, females =0)})$  (The Physical Fitness Specialist Certification Manual, The Cooper Institute, Dallas, TX). During the final week of the training session subjects reported to the lab and repeated all measures done during the initial testing session.

*Exercise Protocol:* Subjects participated in the Army Combative training program for two hours five times per week. Each practice session included calisthenics, technique drills and sparring/fighting rounds. Each exercise session begins with a 30-minute warm-up consisting of bear crawls, burpees, sprawls, break-falls, hip-ups and other various movements to get the fighters' bodies ready for the full-body workout that was about to begin. After the warm-up, fighters moved into the technique portion of class. This period can last up to an hour. During this period of training, fighters did drills to hone their fighting techniques. These drills are very explosive and nonstop. They are designed in such a way that one technique flows into another technique, thus the fighters never stop moving during this time. The remaining class time is used for live sparring. Due to the dynamic nature of Army Combatives, this time could be used for wrestling takedown/judo, submission wrestling, Pankration, boxing, kickboxing or MMA fighting. During this time, the fighter completed multiple five-minute rounds with a one-minute rest between rounds. Additional physical conditioning was discouraged, but all participants were active military personnel, and physical fitness is a mandatory part of their job.

*Statistical Analysis:* Using SPSS, descriptive statistics were determined for all variables. A one-way ANOVA was used to determine significant ( $p < 0.05$ ) differences between groups.

Paired t-tests were used to determine significance ( $p < 0.05$ ) of performance changes seen in the study. Pearson's Correlations were determined between dependent and independent variables.

## Results

*Diet Records:* The control group consumed  $16.49 \pm 4.8$  MJ daily with  $41 \pm 10$  percent of the total energy coming from carbohydrates,  $23 \pm 2$  percent from protein and  $33 \pm 9$  percent from fat. The PRO group was to have a macronutrient breakdown of 40 percent carbohydrates, 30 percent protein and 30 percent fat. They actually consumed  $8.34 \pm 2.2$  MJ, with a macronutrient breakdown of  $36 \pm 10$  percent carbohydrates,  $30 \pm 10$  percent protein and  $35 \pm 8$  percent fat. The CHO group was prescribed a low-fat, high-carbohydrate diet consisting of 65 percent carbohydrates, 15 percent protein and 20 percent fat. The observed diets of this group consisted of  $14.54 \pm 6.9$  MJ,  $58 \pm 10$  percent carbohydrates,  $17 \pm 2$  percent protein and  $26 \pm 10$  percent fat. In terms of percent of total calories per macronutrient, the differences between the prescribed intakes and the observed intakes did not reach significance.

Due to the distinct difference in total energy intake between groups, dietary intake was further analyzed to examine nutrient intake per kilogram of body weight. These results are summarized in figure 4. The control group consumed  $224 \pm 62$  kJ/kg body weight, with an average consumption of  $5 \pm 1$  grams of carbohydrates per kilogram body weight,  $3 \pm 1$  grams of protein per kilogram body weight and  $2 \pm 1$  grams of fat per kilogram body weight. The PRO group consumed  $120 \pm 50$  kJ/kg body weight,  $3 \pm 2$  grams of carbohydrates per kilogram body weight,  $2 \pm 1$  grams of protein per kilogram body weight and  $1 \pm 0$  gram of fat per kilogram body weight. The PRO group took in significantly less protein per kilogram body weight than the prescribed  $3.0 \pm 0.2$  grams of protein per kilogram body weight. The CHO group consumed an average of  $213 \pm 122$  kJ/kg body weight,  $7 \pm 3$  grams of carbohydrates per kilogram body

weight,  $2 \pm 1$  grams of protein per kilogram body weight and  $2 \pm 1$  gram of fat per kilogram body weight. With the exception of the PRO group, the dietary deviations from the prescribed values did not reach a level of significance.

*Performance Measures:* Table 1 summarizes the performance changes. Due to the small sample size, there were no significant differences in changes in performance variables within the dieting groups. Two subjects, one from the CHO group and one from the PRO group, were unable to complete the post-test 600-meter and 1.5-mile run due to injuries. One subject from the PRO group was unable to perform pre-test measures from the 600m and the 1.5-mile run due to injuries. All subjects completed the pre-test and post-test vertical jump test and LPI. The control group did have a significant decrease in their 1.5-mile run time ( $p=0.039$ ), a significant increase in their highest power factor ( $p=0.038$ ) and a significant increase in VO<sub>2</sub>max ( $p=0.39$ ). There were no significant differences in the changes in performance variables between groups, except for the explosive leg power index. The CHO had a significant decrease in the average power factor and highest power factor compared to the control group.

## **Conclusions**

The purpose of this study was to evaluate whether a higher-protein, reduced-calorie diet would hinder athletic performance in fighters who compete in sports with weight classes. The results showed that there was no hindrance to athletic performance when consuming a higher-protein diet. It is important to keep in mind that even though there were not any significant performance benefits observed when consuming more dietary protein, the fact that there were no performance detriments is beneficial compared to current weight cutting practices that do hinder performance. When examining each performance factor, it is important to keep in mind the the PRO group was the only group to consume a hypocaloric diet. The control and CHO group did

improve more than the PRO group in 600 meter shuttle, by the greater caloric intake may have impacted the results of this test. The average vertical jump heights increased the most in PRO group, while this group's highest vertical jump decreased. This decrease may have been due to issues landing on the 27" x 27" inch mat. The LPI remained the same in the PRO group, while the CHO group had a noticeable decrease in LPI.

There was a trend for improvement for the PRO group to decrease their 1.5-mile run time. This is an interesting trend to observe due to previous research showing that a diet with less than 55 percent of its total calories coming from carbohydrates would hinder aerobic performance [31, 32, 33, 37, 38, 39].

Rosenkranz et al [33] reported a case study examining the effects of a low-carbohydrate diet, consisting of 21.5 percent carbohydrates, 23.5 percent protein and 54.7 percent fat, compared to a grain-based diet, consisting of 58.7 percent carbohydrate, 12.1 percent protein and 28.3 percent fat. The individual used in this case study was a male professional triathlete. There was initial testing, and then the subject consumed one of the prescribed diets for two weeks, followed by a five-week washout period, then two weeks consuming the other diet. The end result was that the low-carbohydrate diet increased feelings of lethargy, fatigue and muscle soreness. The triathlete was able to complete each aerobic training session, but the rating of perceived exertion was much greater when on the low-carbohydrate diet. A key difference between this study and the current study was the high level of fat consumed by the subject. Even though protein intake was increased, the greater intake of fat may have been hindering his performance more than a lower-carbohydrate intake. It has been shown that a high-fat diet can hinder performance [31, 32], which is why that study may have found that a low-carbohydrate diet hindered his aerobic performance, when the current study does not validate such a finding.

Also, the low amount of dietary carbohydrates may have limited replenishment of glycogen stores, which would also negatively impact performance.

Macdermid et al [37] performed a study that also compared a high-carbohydrate diet, consisting of 76 percent carbohydrates, 12.5 percent protein and 11.5 percent fat, to a higher-protein diet, consisting of 51.6 percent carbohydrates, 34.7 percent protein and 13.7 percent fat. That study consisted of seven competitive cyclists consuming one of the prescribed diets for seven days along with normal training, which consisted of prolonged bicycle rides each day. The end result was that the high-protein diet caused an increase in time to complete the time trial ride and a decrease in the power output. This finding corresponds with the findings from the Rosenkranz et al [33] study. As seen with the Rosenkranz et al [33] study, the higher-protein diet was high in fat, which seems to negatively impact performance. These two studies differ in the amount of carbohydrates allotted on a higher-protein diet. Consuming 36 percent of one's total calories from carbohydrates should not cause a limitation in glycogen restoration. However, given the high amount of dietary fat consumed, there may have been a shift in the mitochondria to oxidize more fat given the high amount of daily intake. This shift will impact glycogen use and restoration and could have limited performance by causing a greater reliance on fatty acid oxidation for energy production. Using a slower pathway may decrease the rate at which energy is produced and cause a decrease in aerobic performance.

Neither of those previous studies were validated by the current study. The aerobic capacity does not appear to have been hindered by a high-protein diet, and when looking at the explosive leg power index, there does not appear to be a distinct decrease in power output. It is interesting that these two studies have such distinctly different findings. A possible explanation is the protein intake, which was almost twice as much in the Macdermid et al study. Also, the fat



intake was not reported in the Macdermid et al study. As mentioned earlier, a high-fat diet can hinder performance, which may be why the Macdermid et al group reported differing results.

The Zone diet used in this current study has been examined by other researchers. Unfortunately, the results are mixed regarding the impact of the Zone diet on exercise. Chevront et al [35] reported that the carbohydrate intake of the Zone diet was not high enough to sustain optimal endurance performance; however, the carbohydrate intake appears to supply enough glycogen for anaerobic or mixed sports. A one-week study by Jarvis et al [34] reported that the Zone diet has no negative effect on performance. It is unclear which of these researchers is correct when pairing their findings with the findings of this current study. It would appear that the conclusion stating that the Zone diet does not hinder performance would be more accurate; however, further research is needed to validate this idea.

A plausible explanation as to why the Zone diet did not hinder performance is because of the maintenance and possible increase of fat-free mass seen in individuals consuming higher dietary protein [23, 27, 30]. Layman et al [27] conducted a study comparing a higher-carbohydrate diet, consisting of 55 percent carbohydrates, 15 percent protein and 30 percent fat, to a higher-protein diet, consisting of 40 percent carbohydrates, 30 percent protein and 30 percent fat. Each diet in that study was hypocaloric. Those participants were assigned to a prescribed diet for four months. Each diet group was additionally separated into an exercising and non-exercising group. Participants in the two carbohydrate groups were observed to consume a diet consisting of about 61 percent carbohydrates, 18 percent protein and 25.5 percent fat, while participants in the two protein groups were observed to consume a diet consisting of 38 percent carbohydrates, 30 percent protein and 32 percent fat.

All groups in Layman et al [27] study lost weight. The greatest amounts of weight loss were seen in the two groups consuming higher amounts of dietary protein. The protein groups also had a greater amount of fat mass loss compared to the two carbohydrate groups. The higher-protein group not exercising lost some lean mass; however, the higher-protein group that was exercising maintained their lean mass throughout the weight loss. This finding may explain why, in the present study, we did not see a detriment performance when consuming the higher-protein diet. As shown in the Layman et al [27] study, higher-carbohydrate diets used for weight loss, regardless of exercise, can result in significant loss of lean mass. Higher-protein diets plus exercise, such as the diet and exercise regimen used in this current study, lean mass can be retained during the period of weight loss. This retention of lean mass could indicate a retention of muscle mass, thus there were not be a negative impact on performance because there was not a negative impact on overall muscle mass.

There are some limitations to this current study, and the foremost is the small sample size. The higher than expected dropout rate also was a limitation; however, given the demanding schedules of military personnel, a higher dropout rate is unavoidable. It would be advantageous for future research to be done on this area using a larger sample sizes or with athletes that have fewer schedule conflicts. Lack of dietary adherence was also a limitation of this study. It would have been more beneficial for statistical analysis had each group consumed the prescribed macronutrient intake, but the subjects were free living and were allowed to choose their own food. Also, the coaches had the traditional ideology that “cutting weight” via dehydration and exercise in a hot environment 24-hours prior to the event was acceptable. Their attitudes may have impacted the subjects the desire to follow the prescribed diet.

In conclusion, even though these study findings were not statistically significant, the trends do indicate that higher-protein diets do not seem to hinder athletic performance. Current weight cutting practices have been shown repeatedly to not only hinder performance, but also put the athlete's health at risk. Also, lifelong health consequences associated with regular weight cycling have been shown. Further research is needed in this area to determine the benefits of using higher-protein diets for accelerated weight loss in individuals competing in athletics that require weight classification.

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## Figures & Tables

**Figure 1. Dropout rates and reasoning**

n=30	
Job Conflicts	
Work Schedule (n=8)	On Leave from Military Duty (n=2)
Combative Participation Issues	
Did not make team (n=2)	Injured (n=2)
Other Reasons for Leaving the Study	
Family Issues (n=1)	Decided not to participate (n=2)

**Table 1. Changes in performance**

		600m (s)	1.5 mile (s)	VO2 (ml/kg/min)	highest vertical (cm)	average vertical (cm)	highest power factor	average power factor
<b>Control</b>	Pre	67.4 ± 2.7	659.0 ± 27.8	49.1 ± 1.3	66.7 ± 7.3	60.0 ± 6.7	1.13 ± 0.18	1.09 ± 0.17
	Post	64.6 ± 2.3	638.2 ± 23.9	50.0 ± 1.6	64.1 ± 7.7	61.3 ± 8.1	1.67 ± 0.35	1.57 ± 0.34
		-2.8 ± 3.5	-20.8 ± 15.4	1.0 ± 0.7	2.6 ± 2.1	-1.3 ± 10.3	0.54 ± 0.39	0.48 ± 0.41
<b>PRO</b>	Pre	66.5 ± 4.2	694.3 ± 59.4	49.2 ± 5.4	61.5 ± 9.4	59.2 ± 9.4	1.50 ± 0.21	1.39 ± 0.23
	Post	66.4 ± 2.4	620.7 ± 46.3	51.0 ± 5.8	63.2 ± 4.2	56.9 ± 12.3	1.52 ± 0.35	1.46 ± 0.37
		-0.8 ± 2.8	-39.0 ± 8.5	1.8 ± 0.4	-1.7 ± 5.2	2.4 ± 7.9	0.01 ± 0.33	0.07 ± 0.33
<b>CHO</b>	Pre	67.1 ± 2.8	641.5 ± 93.0	53.1 ± 2.7	59.8 ± 10.9	56.5 ± 10.4	1.80 ± 0.47	1.70 ± 0.43
	Post	63.1 ± 0.9	583.0 ± 23.6	53.8 ± 2.4	58.2 ± 12.9	56.1 ± 11.3	1.54 ± 0.58	1.46 ± 0.53
		-4.0 ± 3.5	-14.7 ± 26.3	0.7 ± 1.2	1.7 ± 3.0	0.4 ± 1.5	-0.27 ± 0.33	-0.23 ± 0.27

**Table 2. Initial Group Differences**

Group	Age (yrs)	Height (cm)	Weight (kg)	% Body Fat
Control	27 ± 6	173 ± 5	75 ± 11	14 ± 6
PRO	25 ± 3	178 ± 8	73 ± 11	15 ± 7
CHO	22 ± 2	177 ± 2	76 ± 20	14 ± 10

**Table 3. Prescribed percentage of total energy vs. observed values**

Group	CHO (%) (Rx)	CHO (%) (obs)	PRO (%) (Rx)	PRO (%) (obs)	Fat (%) (Rx)	Fat (%) (obs)
Control	none	41 ± 10	none	23 ± 2	none	33 ± 9
PRO	40 ± 0	36 ± 10	30 ± 0	30 ± 6	30 ± 0	35 ± 8
CHO	65 ± 0	58 ± 10	15 ± 0	17 ± 2	20 ± 0	26 ± 10

**Table 4. Prescribed energy intake vs. observed energy intake (bw = body weight)**

Group	Total Energy (MJ) (Rx)	Total Energy (MJ) (obs)	Total Energy (kJ/kg bw) (Rx)	Total Energy (kJ/kg bw) (obs)
Control	none	16.49 ± 4.8	none	224 ± 62
PRO	10.97 ± 0.8	8.34 ± 2.2	165 ± 10	119 ± 50
CHO	11.63 ± 1.4	14.54 ± 6.9	158 ± 14	213 ± 122

**Table 5. Prescribed values (g/kg body weight) vs. observed values**

	CHO (g/kg) (Rx)	CHO (g/kg) (obs)	PRO (g/kg) (Rx)	PRO (g/kg) (obs)	Fat (g/kg) (Rx)	Fat (g/kg) (obs)
Control	none	5.3 ± 1.5	none	3.1 ± 0.8	none	2.1 ± 1.0
PRO	4.0 ± 0.2	2.8 ± 2.0	3.0 ± 0.2	2.1 ± 0.5	1.3 ± 0.1	1.1 ± 0.3
CHO	6.2 ± 0.6	6.9 ± 3.4	1.4 ± 0.1	2.2 ± 1.4	0.8 ± 0.1	1.7 ± 1.2

**Figure 2. Changes in 600m shuttle time**

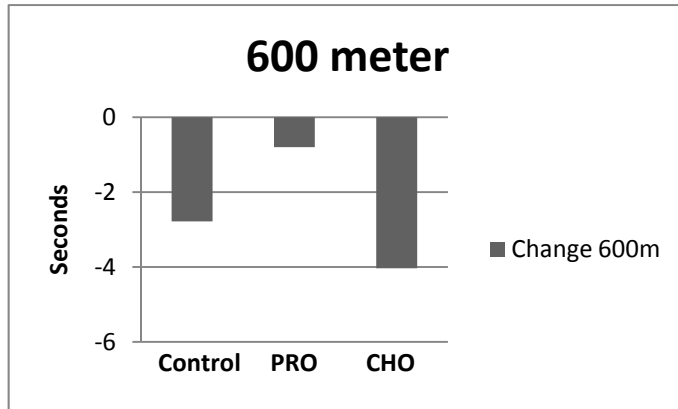


Figure 3. Change in 1.5 mile run times

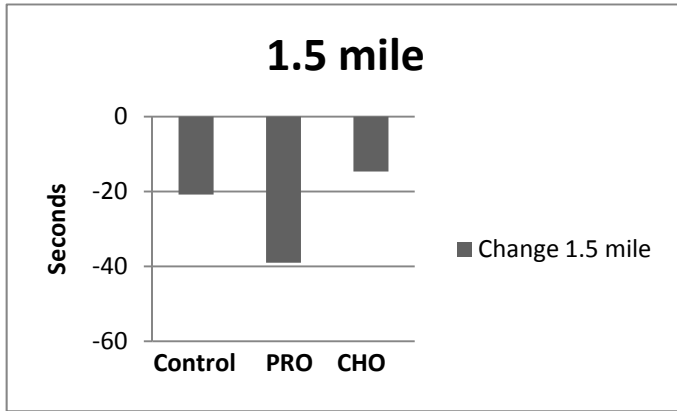


Figure 4. Changes in vertical jump heights

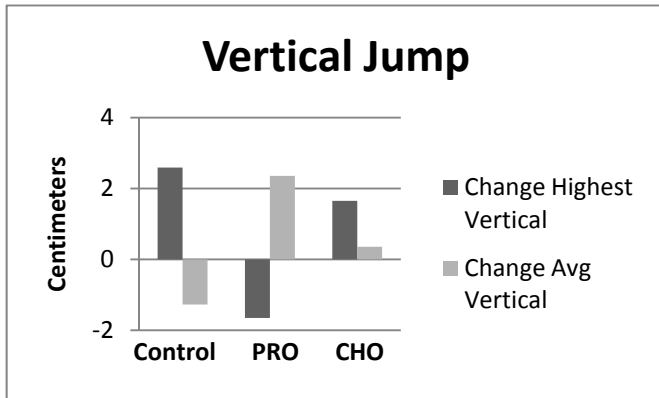
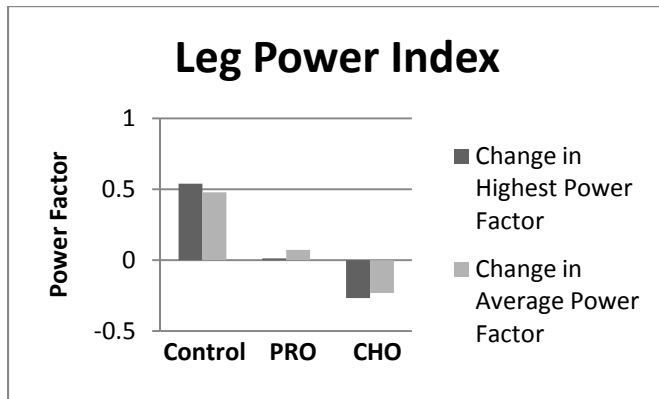


Figure 5. Change in power factors.



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## CHAPTER 4 - Project Summary

The purpose of this study was to examine the effectiveness of using a higher-protein diet (HPD) to induce weight loss and/or improve body composition in active, non-obese individuals. A HPD was defined as having 40 percent carbohydrate, 30 percent protein and 30 percent fat. Active individuals and non-obese individuals attempting to lose weight are not a common research topic, despite the fact that this group makes up 20 to 30 percent of the entire population.

The primary goal of this study further broken down into three specific aims. The first being, examination of the effects of a HPD on weight loss in active, non-obese individuals. HPD have been extensively researched in overweight and obese subsets, as well as sedentary groups. It has been found that HPD elicited greater weight loss, compared to tradition low-fat, high-carbohydrate diet with a nutrient breakdown of 65 percent carbohydrate, 15 percent protein and 20 percent fat. HPD enhancing weight loss by increasing thermogenesis, which can result in increased satiety and decreased subsequent caloric intake. HPD have been shown to improve body composition by maintaining fat-free mass during periods of weight loss. When exercise is combined with dieting, an increase in fat-free has been reported. Another benefit of HPD is greater dietary adherence when compared with other common diet plans.

To further examine the impact of HPD on weight loss, this study recruited active, non-obese subjects participating in structured, supervised activity. There were two distinct training groups of military personnel. One group took part in a six-week training camp, while the other took part in a twelve day training camp, both programs were physically exhausting. The twelve day program consisted of 10 four-hour sessions of supervised physical activity. The six-week training camp consisted of 5 two- hour training sessions weekly.

The primary focus for the shorted training program was to improve body composition by decreasing fat-mass and increasing fat-free mass. All participants in this study were prescribed the same isocaloric, HPD with frequent meals. Unfortunately study participants were unable to adhere to the macronutrient breakdown of the diet given unanticipated mess hall restrictions. Subjects able to consumed frequent meals and snacks. Subjects in this study did have an overall improvement in fat-free mass and a decrease in fat-mass. Potential explanations for the anthropometric changes are physical activity and the consumption of frequent meals and snacks. It is hypothesized that future studies of with a larger subjects size would find that HPD combined with frequent meals and snacks would result in even more improvement in body composition during the brief but intense training.

During the six-week program, subjects were attempting to lose weight and improve body composition. To evaluate the effectiveness of higher protein diet for weight loss and body composition improvement in non-obese, active individuals' three different diets were prescribed. A control diet consisting of no dietary guidelines, but requiring full participation in all supervised activity, a traditional low-fat, high-carbohydrate diet consisting of 65 percent carbohydrate, 15 percent protein and 20 percent fat and a HPD consisting of 40 percent carbohydrates, 30 percent protein and 30 percent fat.

This particular study suffered from a high rate of dropout. Of the subjects that remained, the control group consumed a hypercaloric diet, which resulted in an increase in total weight because of the increase in fat-free mass as was as fat-mass. The HPD group reported consuming a hypocaloric which resulted in a decrease in total weight caused predominantly by decrease in fat-mass. An unexpected finding was that the traditional low-fat, high-carbohydrate group experienced the greatest amount of weight loss while consuming a hypercaloric diet. Upon

further evaluation it was found that one subject consumed a hypocaloric diet and had an eight kilogram weight loss, while the other members of the group were actually consuming a hypercaloric, HPD. The individuals consuming the hypercaloric, HPD had an increase in total weight. The majority of that weight gain came from increases in fat-free mass. Based on this study, it appears that HPD can help maintain fat free mass during periods of weight loss and improve fat-free mass when combined with exercise.

Another aim of this current study was to examine the effects of a HPD on athletic performance. It is important for athletes and active individuals to maintain fat-free mass during weight loss in order to maintain performance levels. Current weight cutting techniques used by mixed martial artists and wrestlers have been repeatedly shown to decreased strength, anaerobic capacity, and aerobic capacity. This study examined power production, a component of muscular strength, via vertical jump and leg power index testing, anaerobic capacity via the 600 meter run, and aerobic capacity via a 1.5 mile run and a mathematical estimation of oxygen uptake. It was found that even during periods of energy deficit, weight loss while on a HPD did not cause a decrease in post-test performance measurements compared to baseline measurements. This is beneficial to the field of sports nutrition because current weight cutting techniques cause a decrease in post-weight loss measures of performance. HPD may provide a more efficient form of accelerated weight loss for active individuals because of the lack of effect on performance.

A third aim of this study was to determine how effective, or to what magnitude, could elicited accelerate weight loss. Unfortunately, we did not observe the magnitude of weight loss that we expected to see given current literature available on a HPD. It is important to keep in mind that the current HPD research focuses on obese, overweight and sedentary individuals. Previous research has shown that various weight loss methods do not elicit the same magnitude

of weight loss in non-obese individuals as seen in their obese counterparts. Another limitation to the magnitude of observed weight loss was small sample size and low dietary adherence. Future research with larger sample sizes and greater dietary adherence is needed to fully determine the magnitude of weight loss that could be seen on a HPD in active individuals.

In conclusion, the current study has some limitations, in particular the small sample size and low dietary adherence, but there appears to be usable information for future studies to benefit the area of sports nutrition. HPD appear to aid in maintenance of fat-free mass during periods of an energy deficit. When HPD and exercise are paired together fat-free mass improve. Frequent consumption of meals and snacks can also help in the maintenance of fat-free mass. Finally, HPD do not appear to cause a detriment to performance.

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## Appendix A - IRB Approval



University Research  
Compliance Office  
203 Fairchild Hall  
Lower Mezzanine  
Manhattan, KS 66506-1103  
785-532-3224  
Fax: 785-532-3278  
<http://urco.ksu.edu>

TO: Mark Haub  
Human Nutrition  
212 Justin

Proposal Number: 4923

FROM: Rick Scheidt, Chair   
Committee on Research Involving Human Subjects

DATE: February 10, 2009

RE: Approval of Proposal Entitled, "Body Composition in Current Military Combatives Participants."

The Committee on Research Involving Human Subjects has reviewed your proposal and has granted full approval. This proposal is **approved for one year from the date of this correspondence, pending "continuing review."**

APPROVAL DATE: February 10, 2009

EXPIRATION DATE: February 10, 2010

Several months prior to the expiration date listed, the IRB will solicit information from you for federally mandated "**continuing review**" of the research. Based on the review, the IRB may approve the activity for another year. **If continuing IRB approval is not granted, or the IRB fails to perform the continuing review before the expiration date noted above, the project will expire and the activity involving human subjects must be terminated on that date. Consequently, it is critical that you are responsive to the IRB request for information for continuing review if you want your project to continue.**

In giving its approval, the Committee has determined that:

- There is no more than minimal risk to the subjects.  
 There is greater than minimal risk to the subjects.

This approval applies only to the proposal currently on file as written. Any change or modification affecting human subjects must be approved by the IRB prior to implementation. All approved proposals are subject to continuing review at least annually, which may include the examination of records connected with the project. Announced post-approval monitoring may be performed during the course of this approval period by URCO staff. Injuries, unanticipated problems or adverse events involving risk to subjects or to others must be reported immediately to the Chair of the IRB and / or the URCO.