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Social cognitive factors associated with moderate to vigorous physical activity in perimenopausal and postmenopausal women

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SOCIAL COGNITIVE FACTORS ASSOCIATED WITH MODERATE TO VIGOROUS PHYSICAL ACTIVITY IN PERIMENOPAUSAL AND POSTMENOPAUSAL WOMEN

by

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An Abstract

Of a thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Health and Sport Studies in
the Graduate College of
The University of Iowa

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Thesis Supervisor: Professor Kathleen F. Janz

ABSTRACT

Osteoporosis (OP) is a disease characterized by low bone mass and structural breakdown of the skeleton. The disease may be prevented through weight-bearing, moderate to vigorous physical activity (MVPA), which is important for peri- and postmenopausal women who are at great risk for OP. However, most women do not participate in activity according to guidelines, which can negatively impact bone health. A better understanding of multi-dimensional factors that influence MVPA may help inform physical activity interventions aiming for OP prevention. The purpose of this study was to utilize social cognitive theory (SCT) to understand the associations between social cognitive factors and MVPA among peri- and postmenopausal women.

Eighty-seven peri- and postmenopausal women (aged 43 to 65) completed this cross-sectional study. Participants completed demographic, health, calcium, and SCT questionnaires. SCT variables assessed included task self-efficacy (SE_T) and barrier self-efficacy (SE_B), perceived social support from friends (SS_{FR}) and family (SS_{FA}), and perceived access to facilities (AC_F) and home equipment (AC_H). Participants wore an NL-1000 pedometer for one week to assess total steps per day and minutes spent in MVPA. Past year MVPA, past week leisure MVPA, and past week occupational/ transport MVPA were assessed with the Modifiable Activity Questionnaire.

Stepwise regression analysis was used to identify the direct relationships between cognitive variables and each of the physical activity outcome measures. Moderation-mediation analysis was conducted to determine if significant interaction effects or confounding effects existed between social cognitive variables and each physical activity variable. Age, income, BMI, and highest level of education were controlled for in all analyses.

Results showed significant relationships between social cognitive factors and each physical activity outcome, supporting the use of such variables for understanding physical activity behavior in peri- and postmenopausal women. For steps per day and MVPA minutes per day, 32% and 26% of the variance in activity was explained. For past year MVPA, past week leisure MVPA, and occupational/transport MVPA, 39%, 26%, and 27% of the variance in activity was explained, respectively. The combination of variables entering the models was different for each physical activity outcome, but overall, SE_B consistently emerged as the most prominent factor. Moderation analyses revealed a three way interaction effect between SE_B, SS_{FR}, and AC_F for steps per day, and two-way interaction effects between SE_B and SS_{FR} for past year MVPA and past week leisure MVPA. Mediation analysis indicated SS_{FA} confounded the relationship between SE_B and past year MVPA.

Results of this study indicate social cognitive factors are directly and indirectly associated with total and MVPA in peri- and postmenopausal women. These relationships should be considered when aiming to develop physical activity intervention programs for prevention of OP in peri- and postmenopausal populations.

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Graduate College
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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

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has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Health and Sport Studies at the May 2010 graduation.

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Eighty-seven peri- and postmenopausal women (aged 43 to 65) completed this cross-sectional study. Participants completed demographic, health, calcium, and SCT questionnaires. SCT variables assessed included task self-efficacy (SE_T) and barrier self-efficacy (SE_B), perceived social support from friends (SS_{FR}) and family (SS_{FA}), and perceived access to facilities (AC_F) and home equipment (AC_H). Participants wore an NL-1000 pedometer for one week to assess steps per day and minutes spent in MVPA. Past year MVPA, past week leisure MVPA, and past week occupational/transport MVPA were assessed with the Modifiable Activity Questionnaire.

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variable. Age, income, BMI, and highest level of education were controlled for in all analyses.

Results showed significant relationships between social cognitive factors and each physical activity outcome, supporting the use of such variables for understanding physical activity behavior in peri- and postmenopausal women. For steps per day and MVPA minutes per day, 32% and 26% of the variance in activity was explained. For past year MVPA, past week leisure MVPA, and occupational/transport MVPA, 39%, 26%, and 27% of the variance in activity was explained, respectively. The combination of variables entering the models was different for each physical activity outcome, but overall, SE_B consistently emerged as the most prominent factor. Moderation analyses revealed a three way interaction effect between SE_B, SS_{FR}, and AC_F for steps per day, and two-way interaction effects between SE_B and SS_{FR} for past year MVPA and past week leisure MVPA. Mediation analysis indicated SS_{FA} confounded the relationship between SE_B and past year MVPA.

Results of this study indicate social cognitive factors are directly and indirectly associated with total and MVPA in peri- and postmenopausal women. These relationships should be considered when aiming to develop physical activity intervention programs for prevention of OP among peri- and postmenopausal populations.

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INTRODUCTION

Osteoporosis is a disease that is characterized by material and structural deterioration of the skeleton. The decreased bone mass and architectural breakdown leads to bones that are porous, weak, and subject to fracture during normal activities of daily living. Osteoporosis (OP) affects 44 million people, and 68% of those are women (USDHHS, 2007). Among men and women, the disease is related to 1.5 million fractures annually that primarily occur in trabecular bone of the hip, lumbar vertebrae/spine, and distal radius. For women the lifetime risk of fracture at any of these sites is 39.7%; among women aged 50 and over, the risk of OP-related fracture is 50% (Melton, 1992). Fractures have significant personal costs for women such as loss of function, disability, and dependence. For example, women sustaining vertebral fractures are 2.4 times more likely to experience chronic pain, are 2.6 times more likely to have functional losses, and 25.3% tend to experience disfigurement (Cummings & Melton, 2002; Nevitt et al., 1998). Women sustaining hip fracture have a 10-24% higher mortality rate than their healthy counterparts, a risk that may persist for five years following fracture (Magaziner et al., 1997). Among survivors, 40% are unable to walk independently, 60% require assistance one year later, and 33% are totally dependent or admitted to nursing homes within one year (Leibson, Tosteson, Gabriel, Ransom, & Melton, 2002).

In addition to the personal cost of OP, the disease has significant social and economic costs. OP has been associated with less social support and difficulty taking on usual social roles with co-workers, family, and friends (Kotz, Deleger, Cohen, Kamigaki, & Kurata, 2004). From an economic standpoint, the direct cost of OP is estimated at 14 billion dollars each year, and with the aging nature of our population, this is expected to double by the year 2050 (Reginster, 2006). Due to these troubling personal, social, and economic costs, prevention of OP is critical.

Osteoporosis Risks and Prevention

Groups at high risk for OP tend to be the focus of health-related intervention research that targets factors known to prevent or reduce the risk of the disease. Some high risk groups include women (when compared to men), those with a family history, women experiencing losses in estrogen, and individuals with sedentary lifestyles. In particular, peri- and postmenopausal women tend to be at high risk for bone loss, largely due to decreases in estrogen that occur during and after the menopausal transition (Hui, Slemenda, & Johnston, 1990; Recker, Lappe, Davies, & Heaney, 2000). According to Eriksen et al. (1988), estrogen directly affects bone by minimizing bone resorption. When estrogen levels decrease during and following menopause, bone mass and architecture also tend to decrease, compromising total bone strength. This takes place to the greatest degree in the metabolically active trabecular bone sites (versus cortical bone). These factors indicate the role of reduced estrogen levels in the loss of bone strength and increased risk of OP among peri- and postmenopausal women (Pacifici, 1996).

The risk of OP is not just linked to bone losses that begin at perimenopause. Instead it is a function of bone accrual early on in life, and then the rate of bone loss following achievement of peak bone mass (PBM). Among females, PBM varies by bone site, but on average it is thought to occur sometime between ages 12 and 20, with site specific peak bone accrual occurring around age 13 (Bailey, Martin, McKay, Whiting, & Mirwald, 2000). After achievement of PBM, bone loss naturally occurs at about 1% per year. Due to more dramatic estrogen losses that begin at perimenopause, the rate of bone loss then increases to about 3-6% per year (Melton et al., 2000). This rate of loss continues for about five to ten years following menopause. Higher rates of loss lead to decreased bone mass and architectural strength, which leads to decreased total bone strength and increased risk for OP and related fracture (Ensrud, 1995). Overall this means that decreasing risk for OP involves maximizing bone accrual during the first two decades of life, or slowing the rate of loss after achievement of PBM in order to optimize bone strength (ACSM, 2004). Therefore, for peri- and post-menopausal women, performance of health behaviors that have the potential to slow the rate of bone loss is a critical step in OP prevention.

Physical Activity and Osteoporosis

For peri- and postmenopausal women, physical activity is a modifiable lifestyle factor that may attenuate the rate of bone loss and decrease the risk for OP (Heinonen et al., 1996; Kemmler, Engelke, Weineck, Hensen, & Kalender, 2003; Nelson et al., 1994). Physical activity is defined as any bodily movement produced by skeletal muscles that results in an increase in energy expenditure above resting levels (Bouchard, Blair, & Haskell, 2007). Components of physical activity include frequency, intensity, time, and type (FITT). Together, all four components refer to dose of physical activity, which is related to many positive health outcomes. A dose-response relationship exists between physical activity and decreased risk of cardiovascular disease, diabetes, certain cancers, symptoms of anxiety and depression, and premature death (Warburton, Nicol, & Bredin, 2006). While the dose-response relation of physical activity and bone health is less clear, the *type* and *intensity* of activity seem to be most important in the preservation of bone.

A number of early research investigations indicated weight-bearing (type), moderate to vigorous (intensity) physical activity is beneficial for bone (Bassey & Ramsdale, 1994; Lanyon, 1996). Weight-bearing moderate to vigorous physical activity (MVPA) can decrease the risk for OP by enhancing or maintaining bone strength through functional mechanical loading of the skeletal system (Lanyon, 1996). Mechanical loading involves forces that have the potential to stimulate bone remodeling (Basssey, Littlewood, & Taylor, 1997). Mechanical loading tends to be present during weight-bearing MVPA, and is theorized to be the primary factor for increases in bone mass and architecture. This increases bone strength and overall bone health, decreasing risk for OP (Bassey & Ramsdale, 1994; Heinonen et al., 1996; Lanyon, 1996).

For peri- and postmenopausal women, the positive effects of mechanical loading on bone are primarily observed through examination of various types of MVPA and bone mass. Bone mass is most commonly quantified by bone mineral density [BMD; g/cm^2]). For example, a positive association between total MVPA and BMD was observed at the hip, lumbar vertebrae of the spine, and radius among peri- and postmenopausal women (Greendale et al., 2003; Zhang, Feldblum & Fortney, 1992). Intervention studies supported these cross-sectional investigations, showing ambulatory activities like brisk walking, jogging, and/or stair climbing performed at a moderate to vigorous intensity significantly increase hip and spine BMD, as compared to losses in BMD among controls (Borer, Fogelman, Gross, & Dengel, 2007; Kemmler et al., 2003; Yamazaki, Ichimura, Iwamoto, Takeda, & Toyama, 2004). Similarly, other forms of moderate to vigorous training such as weight-lifting, jumping, or high velocity resistance training were shown to increase or maintain hip and spine BMD in postmenopausal women, versus losses observed among control groups (Heinonen et al., 1998; Stengel et al., 2005). Overall, these studies support the positive effect of weight-bearing MVPA on bone health among peri- and postmenopausal women. Additionally, these investigations show that when weight-bearing MVPA is *not* performed, known bone losses that occur during middle and late adulthood will persist.

Physical Activity Recommendations and Trends

In response to the large body of research indicating a positive effect of weight-bearing MVPA on bone, as well as the knowledge of bone loss that occurs with physical *in*activity during middle and late adulthood, the American College of Sports Medicine ([ACSM], 2004) issued a position statement on physical activity and bone health. This document includes guidelines designed to slow the rate of bone loss and prevent the progression of OP among adults. According to the ACSM (2004), recommended physical activity for preservation of adult bone health includes performance of a variety of moderate to high intensity, weight-bearing endurance activities like running, jogging, jumping, and brisk walking. These activities should be performed 3-5 days per week for 30 to 60 minutes per day. The recommendations also state adults should perform progressive resistance training exercises, using major muscle groups, 2 to 3 times per week.

Despite the benefits of MVPA for bone and availability of physical activity guidelines for bone health, only 47% of all women participate in activity according to guidelines. Among middle-aged to older women, 38.7% are not participating in physical activity according to guidelines, which may be detrimental to their bone health (USDHHS, 2007). In addition, 13.9% of middle-aged to older women are completely inactive. The low prevalence of physical activity participation among women is of particular concern for prevention of diseases that are associated with inadequate physical activity and primarily affect women, such as OP.

According to the World Health Organization ([WHO], 2009), a host of personal and environmental issues facing middle-aged to older women may contribute to low physical activity participation. Additionally, the menopausal transition may make physical activity participation even more difficult. Potential issues range from physical and emotional menopausal symptoms that have the potential to undermine physical activity, to low perceived social support for physical activity and poor perceived access to physical activity opportunities (Bosworth et al., 2001; Brown et al., 2003; Elavsky & McAuley, 2005; Eventson, Sarmiento, Macon, Tawney, & Ammerman, 2002; King et al., 2000; Thompson et al., 2002; Wing, Matthews, Kuller, Meilahn, & Platinga, 1995). For those already at risk for OP due to decreasing estrogen levels, inadequate physical activity associated with personal and perceived environmental issues increases the likelihood of progressive bone loss and development of the disease.

Understanding and Promoting Physical Activity

In order to promote physical activity for OP prevention, determinants of physical activity behavior for peri- and postmenopausal women must be understood. Over the past several years, much research aimed at understanding and promoting physical activity for both general health and OP prevention has focused on individual psychological determinants of the behavior. The individual psychological determinants that have received a great deal of attention include cognitive, affective, and attitudinal variables such as knowledge, perceived susceptibility (Becker, 1974), perceived self-efficacy

(Bandura, 1982), intentions (Ajzen, 1991), and processes of change (Prochaska & DiClemente, 1983). While knowledge gained from this work has significantly contributed to our understanding of physical activity behavior, only 20-40% of the variance has been explained by these psychological determinants (Godin & Kok, 1996; Spence & Lee, 2002).

The large amount of unexplained variance in psychological determinants research has lead to the notion that physical activity is a dynamic behavior that is likely influenced by multiple dimensions, including individual and environmental factors (Sallis & Owen, 2002). From this perspective, an alternative approach to understanding physical activity behavior is to use a multidimensional framework that reflects the nature of the behavior. Not only can this type of approach reflect the complexity of physical activity behavior, but it may reflect the complex issues facing the peri- and postmenopausal population. As discussed earlier, peri- and postmenopausal women face multi-faceted personal and environmental factors that have the potential to influence physical activity (Elavskey & McAuley, 2005; Evanston, 2002; King, 2000; Thompson, 2002; WHO, 2009). Therefore, in order to more fully understand physical activity behavior for prevention of OP among peri- and postmenopausal women, behavioral determinants should be analyzed in a multidimensional manner.

Social Cognitive Theory

One multidimensional approach that emphasizes the interaction between the person, the behavior, and the environment is Social Cognitive Theory (SCT; Bandura, 1997). SCT (Figure 1) is a view of human functioning that positions people as having the capacity to influence their environment (i.e., agency), rather than simply reacting to innate tendencies or responding passively to the environment (Bandura, 2001). From this perspective, individuals have the ability to exert control over their life circumstances by acting intentionally, with forethought, and in a self-regulating manner (Bandura, 2001; Maddux, 1995). In addition, individuals can reflect upon their thoughts and actions, and use this information to alter future behavior (Bandura, 2001; Maddux, 1995). However, individuals do not have control over their behavior in a completely autonomous manner; instead they do so within a system involving the person, the behavior, and environment (Bandura, 2001).

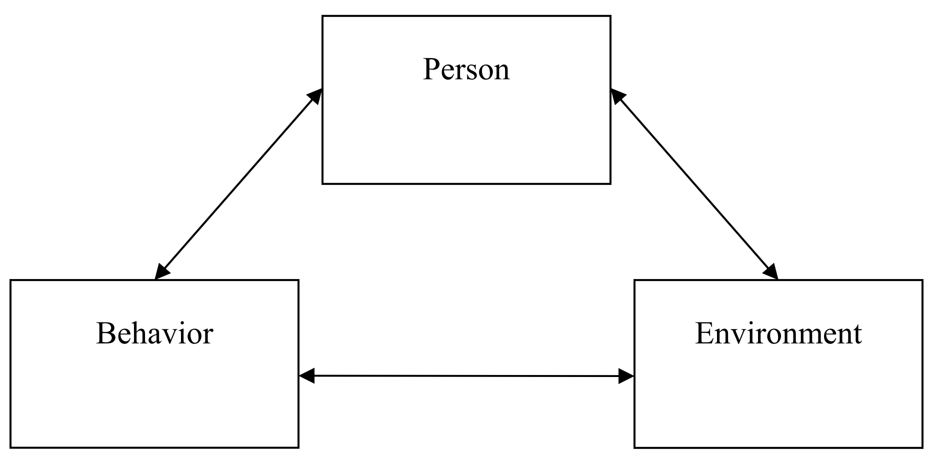

Figure 1. Conceptualization of Reciprocal Determinism in SCT (Bandura, 1989).

Source: Bandura, A. (1978). The self system in reciprocal determinism. *The American Psychologist,* 33(4), 344-358.

According to Bandura (1978), the ongoing interaction between the person, behavior, and environment is referred to as *reciprocal determinism,* where each component acts as a behavioral determinant of the other components (see Figure 1). In this theory, the *person* refers to the cognitions, emotions, and biological characteristics of the individual. The *behavior* refers to the behavior of the individual, and the *environment* refers to the perceived social and perceived physical environment (Bandura, 1978; McAlister, Perry, & Parcel, 2008).

Some theories of human behavior posit behavior to operate unidirectionally, where it is controlled by situational influences (Bandura, 1978). However, in SCT, the reciprocal nature of behavior indicates behaviors are affected by and influence their perceived social and physical environment. However, according to Bandura (1978), the environment typically influences persons through their cognitive processes. That is, cognitive processes determine how the external factor will be perceived and valued, as well as if it will have an effect on current and future behavior.

According to the theory, the environment may influence a person's behavior; but the person also has the capacity (agency) to influence the environment in order to regulate their own behavior (Bandura, 2001; McAlister et al., 2008). Further, once the behavior is performed, personal perceptions of the behavioral outcome have the potential to influence the person or the environment, which may impact future behavior. According to Bandura (1989), the personal influencing forces, the behavior, and the social or physical environment are not equal in strength, nor do they all occur simultaneously or instantaneously. Additionally, they may influence behavior differently based on the specific population or situation. For health behavior, this means the way one component will influence the others varies by population and specific behavior (Bandura, 1978; Bandura, 2004). These reciprocal deterministic relationships between the person, behavior, and environment offer multiple interacting avenues through which we may assess and promote health behaviors like physical activity (Bandura, 1989).

Social Cognitive Determinants of Physical Activity

Within the framework of reciprocal determinism emphasized by SCT, efforts aimed at understanding and promoting physical activity behavior should address the individual, as well as the perceived social and physical environment (Bandura, 1986; Resnick, Orwig, Magaziner, & Wynne, 2002). Most physical activity research utilizing SCT has focused on the individual and social environment, without including an analysis of perceived physical environmental factors (Godin & Kok, 1996; King et al., 2002). Solely focusing on one or two of these areas limits our understanding of the multifaceted nature of physical activity behavior (Baranowski, Anderson, & Carmack, 1998). Inclusion of the perceived physical environment within an SCT framework will allow for a much broader analysis of physical activity behaviors. Applying this broader SCT perspective, physical activity may be partly determined by individual-level psychological factors such as self-efficacy (Bandura, 1997). Additionally, perceived social and perceived physical environmental factors, like social support or access to facilities or home equipment, may facilitate or impede physical activity (Bandura, 1998; McAlister et al., 2008; Sallis & Hovell, 1990; Trost et al., 2002).

Individual Psychological Determinants

Self-efficacy is a core individual-level SCT determinant is consistently identified and supported in the physical activity literature (Bandura, 2004). Self-efficacy may be broken down into two forms, including task and barrier self-efficacy. Task self-efficacy refers to a person's confidence in her ability to perform a specific task in a specific situation (self-efficacy for performing a specific task). Barrier self-efficacy refers to the confidence she has in overcoming barriers when attempting to perform that task or behavior (i.e., self-efficacy for overcoming barriers). According to Bandura (1997), self-efficacy is the single most important determinant of physical activity, as it has the potential to directly and indirectly affect the behavior.

Self-efficacy may be influenced by five mechanisms, including personal mastery experiences, verbal persuasion and encouragement, vicarious experiences, imaginal experiences, and physiological and emotional states (Bandura, 1997; Maddux, 1995). According to self-efficacy theory, the information derived from these five sources functions to influence task and barrier self-efficacy by influencing an individual's perceived task-specific confidence and ability to cope with barriers to task performance. In this way, self-efficacy mediates the influence of the five sources of information on future task participation.

In the context of physical activity, the five influencing mechanisms may be applied to task and barrier self-efficacy in peri- and postmenopausal women. For example, *personal mastery experiences,* such as women's successful performance of weight-bearing MVPA may strengthen her task and/or barrier self-efficacy. That is, if she can perform the skill once (i.e., task self-efficacy) and if she can do so in the face of barriers such as lack of time (i.e., barrier self-efficacy), she is likely to believe that she will be able to do it again (Maddux, 1995).

Verbal persuasion or encouragement from a trustworthy and knowledgeable source to engage in activity can reinforce a woman's confidence in her ability to perform physical activity (Maddux, 1995). For instance, if a friend who is knowledgeable about exercise provides "how to" advice, offers to exercise with her, or offers transportation to an exercise facility, these factors could enhance the woman's belief she can perform the task (e.g. someone will show me or tell me how) or overcome obstacles to performing that task (e.g., lack of transportation). The same may be said of *vicarious experiences*, where a woman who observes family members or friends successfully engaging in physical activity, and sees them doing so in the face of barriers, is more likely see the behavior as doable (Maddux, 1995). This is particularly true if the outcomes of their behaviors are perceived by the woman as positive (e.g., "I want to feel healthy too").

Imaginal experiences may also influence task or barrier self-efficacy through visualization of successful performance and anticipating the emotional or cognitive results of task performance (Maddux, 1995). For instance, a woman may enhance her task self-efficacy beliefs by visualizing herself doing physical activity. She could also enhance her belief in her ability to overcome barriers by visualizing herself performing activity despite an obstacle, such as seeing herself exercise despite her fatigue at the end of the workday. Finally, p*hysiological and emotional states* of peri- and postmenopausal women, such as fatigue, hot flashes, and feelings of depression, could undermine her task (e.g., lack of physical stamina) or barrier self-efficacy expectations (e.g., feels ill, mentally drained), decreasing the likelihood of activity participation. However, understanding physical activity may alleviate her symptoms or eventually give her more energy may support her self-efficacy expectations. In addition to the five sources of self-efficacy information, recent investigations established a link between the perceived social and physical environment with self-efficacy (Blanchard et al., 2005; Cerin et al., 2008). This indicates the influence of self-efficacy on physical activity directly and indirectly. Through these mechanisms, physical activity self-efficacy may be influenced by personal, perceived social, and perceived physical environmental factors (Resnick & Spellbring, 2002).

Previous research supports the relationship between physical activity and self-efficacy among peri- and postmenopausal women. In cross-sectional analyses, task self-efficacy is shown to be positively associated with weight-bearing physical activity levels among peri- and postmenopausal women (Ali & Twibell, 1995; Estok, Sedlak, Doheny, & Hall, 2007; Swaim, Barner, & Brown, 2008). Barrier self-efficacy is also shown to play an important role in adoption and maintenance of physical activity in longitudinal investigations of older women (Resnick & Spellbring, 2000) and cardiac rehabilitation patients (Reid et al., 2007). Interventions aimed at enhancing self-efficacy support these findings, demonstrating increased physical activity adherence among women participating in an OP education program (Piasau, Schepp, & Belza, 2002) and among healthy older adults (Brassington et al., 2002).

Perceived Social and Physical Environmental Determinants

The perceived social and perceived physical environment is also shown to directly influence physical activity behavior (Blanchard et al., 2002; Booth et al., 2000; Giles-Corti & Donovan, 2002). Similar to ecological models of health behavior, SCT suggests the perceived social and perceived physical environment may facilitate or inhibit physical activity behavior. For example, social resources may be provided or the physical environment may be restructured in a way to promote or provide perceived opportunities for physical activity. When the social or physical environment is then perceived by the individual as conducive to physical activity, she will be more likely to engage in activity (Bandura, 1998). It should be noted, however, that even when social resources or the physical environment are intended to enhance physical activity, if they are not perceived as conducive, they have the potential to undermine activity (Bandura, 1998). Further, the social resources and perceived physical environmental characteristics that are conducive for activity are not always the same for men and women, which is important for understanding and promoting women's physical activity behavior (Humpel, Owen, Iverson, Leslie, & Bauman, 2004).

Social environment: Social support. In terms of the perceived social environment, perceived social support is consistently supported in the physical activity literature (Trost et al., 2002). Social support may be broadly defined as the assistance afforded through social relationships and interactions, but it may be more specifically broken down by type or source (Heaney & Isreal, 2002). There are four different types of social support, including emotional (caring), instrumental (tangible), informational (advice), and appraisal (feedback) support (House, 1981). Among adults, this support often comes from family, friends, co-workers, or health care providers. It is assumed that the support provided by these groups is intended to be positive or helpful, but the receiver of the support may not perceive it as positive.

Most research does not specify which type of social support is most important. However, research that does examine type of support indicates emotional and informational support from family and friends may be most important for healthy women (Eyler et al., 1999). Additionally, the degree to which social support influences physical activity may vary by age, where in comparison to young females, greater influence of social support on physical activity has been found in middle to older aged females (DeBourdeaudhuij & Sallis, 2002). In general, higher levels of social support from family and friends are identified as important determinants of physical activity behavior among women, older adults, and overweight populations (Blanchard et al., 2005; Booth et al., 2000; Castro et al., 1999; Eyler et al., 1999). Interestingly, social support is also associated with frequency, intensity, and duration of activity (Eyler et al., 1999), and it may be especially important for MVPA performed in the leisure domain (Sternfeld, Ainsworth, & Queensberry, 1999).

Physical environment: Access to facilities and home equipment. In addition to the social environment, the influence of perceived physical environmental factors on physical activity is also supported in the literature (Blanchard et al., 2005; Humpel et al., 2004; Reid et al., 2007). The direct associations between perceived physical environmental factors and physical activity indicate their role in providing support or structures that can facilitate physical activity behavior. However, from an SCT perspective, it is not enough for an ideal environment to simply exist; to facilitate activity, it must also be perceived as favorable for physical activity.

In the physical activity determinants literature, two perceived environmental factors that have emerged include access to home equipment and recreational facilities (Trost et al., 2002). Perceived access to facilities and home equipment are shown to be positively associated with increased physical activity levels of middle-aged to older women. In addition, access to convenient facilities, especially walking paths and exercise facilities are associated with higher levels of walking activity (Brownson et al., 2000; Ball et al., 2001). Further, these associations may be stronger for women than for men (Humpel et al., 2004), indicating perceived access to facilities or equipment may help women overcome barriers (e.g., time constraints due to care giving responsibilities) to weight-bearing ambulatory activity (Ball et al., 2001; King, 2000).

Interplay Between Social Cognitive Determinants

In addition to being independently associated with physical activity, self-efficacy may work in conjunction with perceived social and perceived physical environmental factors when predicting physical activity (Blanchard et al., 2005; Hsieh et al., 2008; Resnick et al., 2002). For instance, perceived self-efficacy may mediate the association between social support and physical activity among middle and older aged women (Hsieh et al., 2008; Resnick, et al., 2002). Interestingly, Blanchard et al. (2005) found an interaction between adult social support and self-efficacy, where social support was associated with physical activity, especially when self efficacy was higher. These researchers (Blanchard et al., 2005) also identified a similar interaction between access to facilities and self-efficacy, where the association between access and physical activity was stronger when self-efficacy was higher. These findings indicate that interventions aimed at increasing physical activity should target self-efficacy and perceived social and physical environmental factors.

Because the individual, perceived social, and perceived physical environmental determinants have received considerable support in the physical activity literature, these social cognitive factors were included in this study. Individual factors included task self-efficacy and barrier self-efficacy. Social factors included perceived social support from family and friends, and environmental factors included perceived access to facilities and home equipment.

Measurement of Physical Activity

Just as behavioral determinants of physical activity should be measured in a multi-faceted way, physical activity should also be measured in a multi-dimensional manner. Physical activity is a complex, dynamic, behavior that is comprised of many components (FITT), may be performed in a variety of domains (i.e., leisure, occupational, transport) and contexts (i.e., neighborhood, home, gym), and varies by population. Therefore, assessing physical activity behavior in specific populations, like peri- and postmenopausal women, requires comprehensive methods that can capture the dynamic nature of the behavior.

In determinants research, measurement of physical activity generally relies upon self-report methods due to the large sample sizes involved and the low cost of the instrument (Tudor-Locke & Myers, 2001). However, there are significant errors inherent in self-report instruments, especially issues associated with social desirability, misinterpretation and translation, conceptualization of physical activity performed and accumulated in various domains, and problems with recall (Tudor-Lock & Myers, 2001). Among women, the primary issues lies in the conceptualization and capture of activities performed in non-leisure domains (Ainsworth, 2000; Kriska, 2000; Sallis & Owen, 1999). People struggle to report more light and moderate amounts of physical activity, particularly when it is performed in non-leisure domains, where women perform much of their activity. This makes it difficult to capture true patterns of physical activity and discern the importance of activity performed throughout the day. Activity performed in non-leisure domains may be especially relevant for women who, in their traditional familial and social roles, tend to perform much of their activity in and around the home and while caring for family members (Ainsworth, 2000).

Objective monitors such as accelerometers and pedometers help to circumvent above-described issues associated with self-report instruments. Objective monitors provide time-stamped measures of volume of activity, and accelerometers and some pedometers provide measures of activity intensity (Corder, Brage, & Ekelund, 2007). In doing so, these devices are able to detect activity that people are not able to recall or that they do not even think of as activity, like accumulated walking in a variety of domains and contexts. This is important because accumulated activity is central to many physical activity guidelines, and walking may be one of the most common forms of weight-bearing physical activity performed in the general population (Tudor-Locke, & Myers, 2001). Additionally, ability to measure intensity of activity is significant because intensity is critical for bone health, and as such, it is emphasized in current ACSM recommendations (2004). However, objective monitors also have their limitations, including the inability to assess load-carrying, upper-extremity movement, water activity, and poor capturing of non-ambulatory movement like biking. Further, these instruments may malfunction; they have lower compliance than self-report; and provide no direct information about domain or context (Dale, Welk, & Matthews, 2002).

Both self-report and objective measures of physical activity have their strengths and weaknesses. In order to advance the current understanding of physical activity behavior among peri- and postmenopausal populations, utilization of both methods in relation to behavioral determinants seems to be the best, most contemporary solution (Tudor-Locke & Myers, 2001). Subjective measures will allow determinants researchers to examine factors associated with physical activity levels performed in specifically measured domains. Objective measures will allow researchers to examine determinants associated with quantifiable, ambulatory, weight-bearing activity performed at or above specified intensities. Identifying these factors is relevant in light of (a) current ACSM (2004) recommendations that indicate type and intensity are the most important components of physical activity for bone health, and (b) recent research indicating women may not perform this activity in any single domain (Greendale et al., 2000; Ainsworth 2000).

Significance of the Study

Osteoporosis is a debilitating disease that is a growing public health concern, particularly for women. Because of the prevalence of the disease, as well as the significant personal, social, and economic consequences, prevention of OP is imperative. This is especially true for high-risk groups like peri- and postmenopausal women. One way the risk for OP may be reduced is through performance of weight-bearing MVPA according to guidelines (ACSM, 2004; USDHHS, 2007). While the ACSM (2004) guidelines for physical activity and bone are available to the public, as the physical activity prevalence data demonstrate, most women are still not meeting recommendations (CDC, 2007). Therefore, promotion of physical activity through behavioral determinants research is a critical area of study that may pave the way for the design of more effective population-specific interventions. Thus, interest in individual-level psychological determinants research has seen tremendous growth among researchers, practitioners, and public health officials. While this has added to our understanding of physical activity behavior, much unexplained variance remains (Spence & Lee, 2002). This indicates alternative approaches that reflect the multi-dimensional, complex nature of physical activity are warranted (Sallis & Owen, 2002).

SCT may provide a framework by which we can examine multifaceted determinants of physical activity behavior among specific populations. SCT allows the study of physical activity behavior through analysis of individual, perceived social, and perceived physical environmental determinants. To date, however, the study of OP preventive behaviors has focused almost entirely on individual-level psychological determinants, with only one study examining social factors associated with such behaviors (Hseih et al., 2008). Because of the dynamic nature of physical activity, as well as the complex issues peri- and postmenopausal women face, a broad SCT perspective should provide valuable insight into individual, social, and environmental factors associated with physical activity. Further, pairing an SCT approach with objective and subjective physical activity measures may reveal the interacting nature of these associations with domain and intensity-specific physical activity. Such information could inform health promotion efforts aimed at promoting MVPA as an OP preventive behavior among peri- and postmenopausal women.

Purpose of the Study

The purpose of this study was to utilize SCT to understand and describe pre-selected determinants of MVPA among peri- and postmenopausal women. Specifically, this study examined relationships between individual, social, and environmental determinants and the MVPA of peri- and postmenopausal women. In addition, to gain a better understanding of physical activity performed by peri- and postmenopausal women, physical activity was measured objectively and subjectively.

A second objective of this study was to examine the variance in MVPA explained by the individual (task and barrier self-efficacy), perceived social (perceived social support from family and friends), and perceived environmental (perceived access to facilities and home equipment) factors. This involved understanding which factors were most important overall, and among those, which made the largest contribution in explaining the MVPA of peri- and postmenopausal women.

Finally, this study identified the strengths of the direct and indirect relationships found among individual, social, and environmental factors with MVPA. This allowed for a deeper understanding of the direct and indirect relationships between a factor or sets of factors and MVPA in this population.

By meeting the objectives of this study, researchers, practitioners, and public health officials may be provided with information about select individual, social, and environmental determinants of physical activity behavior for OP prevention. This information was specific to an important at-risk group – peri- and postmenopausal women. Identifying the overall and relative contribution of the individual, social, and environmental determinants of physical activity provided information that may help guide researchers, practitioners, and public health officials in planning and prioritizing physical interventions for OP prevention. Additionally, description of the direct and indirect relationships between determinants and physical activity could allow researchers to understand the importance of intervening on more than one determinant simultaneously, or how intervening on one determinant may impact the association between another determinant and physical activity. Overall, achievement of these objectives may help inform future research and health promotion interventions aimed at decreasing women's risk for OP, ultimately helping women attenuate or even avoid the loss of function and decreased quality of life that accompanies this disease.

Research Aims

The primary objective of this study was to determine if pre-selected determinants of physical activity can be used to understand physical activity behavior among peri- and postmenopausal women. The specific aims of this study were to:

1. Describe select factors associated with the MVPA of peri- and postmenopausal women. More specifically, this included an examination of:

   Individual: Task and barrier self-efficacy;

   Social: Social support from friends and family; and

   Environmental: Perceived access to facilities and home equipment.

2. Test the relative contribution of the individual, social, and environmental factors in explaining the MVPA of peri- and postmenopausal women.
3. Describe the strength of the direct and indirect associations of individual, social, and environmental factors in explaining the MVPA of peri- and postmenopausal women.

Delimitations

This study was delimited to peri- and postmenopausal women from Eastern Iowa and Western Illinois. The participants were between the ages of 45 and 65 at the time of this study.

Limitations

The participants who were recruited for this study were volunteers and were from the Midwestern segment of the United States. This could limit the generalizability of the results, as this sample may not be representative of the general peri- and postmenopausal population.

The objective measurement of physical activity was a strength of this study, but objective monitors were not without limitations. Some limitations included the inability to assess load-carrying, upper-extremity movement, water activity, and poor capture of non-ambulatory movement like biking. Additionally, the pedometers used in this study did not time-stamp physical activity through each day of wear, therefore information about a complete day of wear (eight hours) was based on information reported by the participants on the provided monitor on/off log.

Assumptions

There were several assumptions for this study. The researcher assumed the participants wore the activity monitor according to instructions; participants followed instructions for subjective physical activity assessment and determinants questionnaires; and participants responded truthfully and accurately to the physical activity assessment and determinants questionnaires. Additionally, the researcher assumed the women who volunteered in the study provided accurate information about their menopausal status.

Definitions

Access to facilities (AC_F): A perceived physical environmental characteristic that refers to convenient access to facilities that offer recreational or physical activity opportunities. Convenient refers to facilities that are on a frequently traveled route, within a 5-minute drive, or within a 10-minute walk from home or work.

Barrier self-efficacy (SE_B): A component of self-efficacy that refers to the confidence one has in overcoming barriers to performing a specific behavior in a specific situation (Bandura, 1997). In this study barrier self-efficacy would include confidence in one's ability to exercise despite barriers such as lack of time, fatigue, or family obligations.

Bone architecture: Bone architecture refers to the structural properties of bone, which involves bone geometry such as size, shape, cross-section, cortical thickness, and arrangement (Khan et al., 2001).

Bone (mineral) mass: Bone mass refers to the material properties of bone which includes organic (collagen) and inorganic (calcium) compounds. The most common outcome measure of bone mass is bone mineral density (BMD) (Khan et al., 2001).

Bone mineral content (BMC, g): BMC refers to total grams of bone mineral as hydroxyapatite within a measured bone region (Khan et al., 2001).

Bone mineral density (BMD, g/cm^2): BMD is an areal bone density that refers to grams of bone mineral per unit of bone area scanned, as measured by dual x-ray absorptiometry ([DXA]; Khan et al., 2001).

Dose-response: A relationship that refers to the dose of physical activity required to elicit a specific response or benefit (Bouchard et al., 2007).

Frequency: The number of times a defined bout of physical activity is performed over an established period of time. Typically referred to as accumulated or continuous sessions per week.

Intensity: The level of exertion or magnitude of work performed during a physical activity bout, often classified as light, moderate, or vigorous (CDC, 2008). This may include the level of energy expenditure for endurance activity, force produced by skeletal muscle for resistance or strength training, or velocity of muscle shortening for power training.

Moderate- intensity physical activity: Physical activity, such as brisk walking or bicycling on primarily flat terrain, that is intense enough to raise heart rate and cause a sweat response. It is often quantified as 3.0 to 5.9 times the effort expended at rest (CDC, 2008).

Moderate to vigorous physical activity (MVPA): Encompasses physical activity that may be classified as moderate or vigorous intensity. It may be quantified as 3.0 or more times the effort expended at rest.

Osteogenesis: A bone-building response caused by mechanical loading forces that meet the minimal threshold required to stimulate osteoblasts, the cells responsible for a positive bone response. A positive bone response in this study may refer to bone building, maintenance, or a slower rate of bone loss caused by physical activity (Khan et al., 2001).

Osteoporosis (OP): Disease of the skeletal system characterized by low bone mass and increased bone fragility, such that bones become porous and subject to fracture. OP is clinically measured and defined as a DXA-derived BMD T-score of at least 2.5 standard deviations below the Caucasian female adult peak mean (USDHHS, 2007; WHO, 1981).

Osteopenia: Condition of the skeletal system that is characterized by bone mass that is below normal, often referred to as a precursor to OP. Osteopenia is clinically defined as a DXA-derived BMD T-score of 1 to 2.5 standard deviations below the Caucasian female adult peak mean (Khan et al., 2001 WHO, 1981).

Physical activity: Bodily movement that is created by skeletal muscle that causes an increase in energy expenditure above resting levels (Bouchard et al., 2007).

Peak bone mass (PBM): The highest level of bone mass achieved. This varies by skeletal site but is thought to occur sometime between age 14 and 20 to 30.

Perimenopausal: Alteration in menstruation due to a decline in ovarian follicular activity. This may include irregular cycles or cessation of menstruation for less than one year (WHO, 1996).

Postmenopausal: Cessation of menstruation for one year or more due to ovarian follicular inactivity (WHO, 1996).

Self-efficacy (SE): One's confidence in their ability to perform a specific task in a specific situation, and to overcome potential barriers in order to perform the specific behavior. Thus, this study conceptualized self-efficacy as a two-component concept, including both task and barrier self-efficacy. (See task self-efficacy; See barrier self-efficacy).

Social support (SS): Aid or assistance afforded through social relationships and interactions that may vary by source or type of support. Sources of support may include individuals or groups close to the individual such as family, friends, co-workers, and healthcare providers. Types of social support include emotional (love, empathy, caring), instrumental (assistance with tangible needs), appraisal (feedback, assistance with decisions), and informational (advice or information; Heaney & Isreal, 2002). For this study, perceived social support from friends (SS_{FR}) and family (SS_{FA}) will be examined.

Social Cognitive Theory (SCT): Theoretical framework that explains human behavior in terms of a triadic, dynamic, and reciprocal model (Bandura, 1997). Within the SCT, the person (cognitions, biological factors), environment (social and perceived physical), and behavior all interact. This theory focuses on human agency or the ability to alter the environment for specific purposes or desired outcomes (Baranowski et al., 2002). For this study the personal or individual factors included task and barrier self-efficacy; social environmental factors included social support from family and friends; and perceived physical environmental factors included perceived access to facilities and home equipment; and the behavior included physical activity.

Targeted loading activities: Force generating activity that elicits a stimulus to a specific bone site or region above and beyond that produced by normal daily activities (Khan et al., 2001).

Task self-efficacy (SE_T): A component of self-efficacy that refers to confidence in one's ability to perform a specific task in a specific situation (Bandura, 1997).

Time (Duration): This typically refers to the length of an exercise bout for endurance training. For resistance, strength training, or power training this may include the number of exercises, sets, and repetitions performed.

Volume: The volume or amount of physical activity is typically the product of frequency, intensity, and duration.

Vigorous-intensity physical activity: Physical activity, such as jogging or bicycling on primarily hilly terrain, that is intense enough to significantly raise heart rate and breathing rate. It is quantified as 6.0+ times the effort expended at rest (CDC, 2008).

Weight bearing physical activity (WBPA): Physical activities that impart a load on the skeletal system through the creation of ground reaction forces (Howley & Franks, 2003).

CHAPTER II

LITERATURE REVIEW

The literature review for this study first provides a brief overview of the magnitude and impact of osteoporosis with respect to peri- and postmenopausal women. Secondly, this review discusses research relating to the importance of physical activity for enhancing bone health and decreasing risk of OP. An overview of current trends in women's physical activity is presented. This is followed by a review of Social Cognitive Theory (SCT), and then application of SCT to the present study, focusing on individual, social, and perceived physical environmental factors associated with physical activity. A detailed review of literature measuring social cognitive determinants of physical activity is then presented, including task and barrier self-efficacy; social support from family and friends; and perceived access to facilities and home equipment. Finally, physical activity measurement issues relevant to this study are discussed.

The Impact of Osteoporosis among Women

Osteoporosis (OP) is a disease that is characterized by material and structural deterioration of the skeleton that causes bones to become more porous, weak, and subject to fracture under the stresses of normal daily activities. According to epidemiologic studies, in the United States alone, OP affects 44 million men and women. While OP can affect any individual, regardless of gender, 68% of those afflicted are women (USDHHS, 2007). The reduction in bone strength among women markedly increases the risk for skeletal fractures at the hip, lumbar vertebrae, and radius. Fractures occurring at all sites, but especially at the hip and lumbar vertebrae, have significant personal costs for women such as pain, loss of function, disability, and dependence (Nevitt et al, 1998; Leibson et al., 2002). Among women, there are also considerable social consequences of the disease such as fear, more necessary life adaptations, low perceived health, pessimism, and diminished social interactions with co-workers, family, and friends (Kotz et al., 2004 Martin et al., 2002). Overall, the consequences of OP-related fractures have the potential to negatively impact women's quality of life (Reginster & Burlet, 2006).

A number of personal factors are associated with an increased risk for OP among women, including advancing age, small body size, family history, smoking, and excess alcohol consumption (Dawson-Hughes, Krall, & Harris, 1993). Sedentary lifestyles and poor calcium/vitamin D intakes are also significant predictors of increased OP risk in women, and these associations remain strong when controlling for other aforementioned risk factors (Devine, Dhaliwal, Dick, Bollerslev, & Prince, 2004; Nguyen, Center, & Eisman, 2000;Uusi-Rasi, Sievanen, Pasanen, Oja, &Vuori, 2002). Additionally, one of the best predictors of OP is the alteration in estrogen levels associated with menopausal changes that begin at perimenopause and extend into postmenopause. In fact, estimates indicate 30% of all postmenopausal women have OP (Melton, O'Fallon, & Riggs, 1987; Melton et al., 1992). Further, research suggests 50% of postmenopausal women with no previous diagnosis of OP have low bone density and will likely sustain an OP-related fracture in their lifetime (Melton et al., 1992). Overall, the magnitude and impact of OP underscores the importance of disease prevention; and this is especially critical for peri- and postmenopausal women who are at high risk for developing OP.

Physical Activity and Osteoporosis

For peri- and postmenopausal women, physical activity is a modifiable lifestyle factor that may slow the material and structural breakdown of bone and decrease the risk for OP (Heinonen et al., 1996; Nelson et al., 1994; Nguyen et al., 1998; Stengel et al., 2005). Evidence indicates weight-bearing, moderate to vigorous physical activity (MVPA) seems to be particularly important for the preservation of bone (Bassey & Ramsdale, 1994; Hagberg et al., 2001; Lanyon, 1996; Nelson et al., 1994; Stengel et al., 2005; Yamazaki et al., 2004).

Mechanical Loading through Physical Activity

Weight-bearing MVPA can decrease the risk for OP by enhancing or maintaining bone strength through functional mechanical loading of the skeletal system (Lanyon, 1996). Mechanical loading of the skeletal system may result from three primary forces that have the potential to stimulate bone remodeling, including axial compressive, bending, and muscle-pulling forces (Bassey, Littlewood, & Taylor, 1997). Optimal mechanical loading characteristics tend to be present during weight-bearing MVPA, and are theorized to be primary factors for increases in bone mass and architecture, thus increasing bone strength and overall bone health (Bassey et al., 1997; Heinonen et al., 1996; Liu-Ambrose, Khan, Eng, Heinonen, & McKay, 2004; Rubin et al., 2004; Rubin et al., 2002).

The positive effects of mechanical loading on bone are observed among peri- and postmenopausal women through examination of various types of MVPA and bone mass. In these investigations bone mass is most commonly quantified by bone stiffness measured with Quantitative Ultrasound QUS) or through bone mineral density ([BMD]; g/cm^2) measured with Dual X-Ray Absorptiometry (DXA). Although QUS has been shown to be a reliable estimate of hip and spine BMD (Faulker, et al., 1994; Gluer et al., 2004), DXA is considered to be the most accurate measure of BMD and, as such, is the primary measure reported in the literature. Research focusing on the association of physical activity with bone has included an examination of total MVPA; ambulatory MVPAs that generate ground reaction forces like brisk walking, jogging, or stair-climbing; muscular MVPAs that create muscle pulling forces such as jumping, weight-lifting, or high velocity resistance training; and combinations of ambulatory and muscular MVPAs (Greendale et al., 2003; Heinonen et al., 1998; Kemmler et al., 2003; Yamazaki, et al., 2004; Zhang et al., 1992).

Relationship between Habitual MVPA and Bone

Total habitual MVPA performed by peri- and postmenopausal women has been studied in relation to BMD. Zhang et al. (1992) conducted a cross-sectional examination of the association between objectively- and subjectively-measured physical activity and BMD. Participants included 352 perimenopausal women, aged 40 to 54 years. BMD was assessed by dual photon absorptiometry at the lumbar spine, mid-radius, and distal radius. Current physical activity was assessed objectively with a Caltrac accelerometer worn for at least three days. Self-reported high-school physical activity was also measured. Researchers reported that each additional 100 kcal/day in energy expenditure was associated with higher bone density, at the lumbar spine (12 mg/cm^2), at the distal radius (3.8 mg/cm^2), and at the mid-radius (3.5 mg/cm^2). This relationship was maintained after accounting for factors such as age, body mass, and high school physical activity. Researchers concluded that current MVPA, measured objectively, is beneficial for BMD among perimenopausal women.

In order to investigate the association between physical activity and bone in a slightly older population, Hagberg et al. (2001) examined the relationship between total physical activity and BMD among postmenopausal women aged 60 to 68 years. This cross-sectional study was conducted as a part of a larger longitudinal bone health study based out of the University of Pittsburgh Medical Center. For this cross-sectional study, BMD was assessed at the total body, lumbar spine, and hip via DXA. Level of physical activity was identified and women were classified into three activity levels, including sedentary, moderately active non-athletes, and competitive endurance athletes. Researchers found those participating in regular moderate physical activity had 7%, 8%, and 18% higher BMD in the total body, lumbar spine, and hip than those who were classified as sedentary. This provides more support for the association between moderate activity and BMD in postmenopausal women.

The above-described positive associations between total MVPA and bone may vary when physical activity domain is considered (Greendale et al., 2003). Greendale and colleagues (2003) examined the association of sport, home, work, and daily living activity with BMD of the lumbar spine and hip among 2277 pre- and perimenopausal women, aged 42 to 52 years. The participants were currently part of the longitudinal Study of Women's Health across the Nation (SWAN). For the cross-sectional portion of this study, researchers assessed BMD of the lumbar spine and hip through DXA. Physical activity was assessed subjectively through the Kaiser Physical Activity Scale ([KPAS]; Ainsworth, Sternfeld, Richardson, & Jackson, 2000), which assesses physical activity in four domains, including sport, home, work, and daily routine/active living. Researchers found perimenopausal women classified in the higher tertiles of sport and home activity had 2.1% and 1.7% higher lumbar spine BMD and 2.6% and 1.7% higher hip BMD than those in the lower tertiles of sport and home activity, respectively. This is a relevant finding for women who may be likely to engage in a significant amount of leisure and home activity that could be beneficial for bone (Ainsworth, 2002).

Cross-sectional investigations demonstrate the association between total MVPA and BMD, but cross-sectional findings provide no evidence of causality. On the other hand, longitudinal investigations provide a temporal component that can support a causal association between total MVPA and bone. However, longitudinal studies provided conflicting results. For instance, the Dubbo Osteoporosis Epidemiology Study ([DOES]; Nguyen et al., 1998) demonstrated physical activity slowed the rate of bone loss among 827 postmenopausal women aged 60 years and over. These researchers examined the effects of changes in habitual physical activity over 2.7 years on hip BMD. BMD was determined by DXA and a customized Framingham Heart Study physical activity score was measured by quantifying time spent each day in sleep/laying down, sedentary, light, moderate, or heavy activity. The researchers found those who had a moderate physical activity index lost significantly less hip BMD (-0.55%) as compared to sedentary women (-1.35%). They also found evidence for a causal relationship between MVPA and BMD, and concluded that MVPA may slow the rate of bone loss at the hip in older women.

Relationship between Ambulatory MVPA and Bone

In addition to total MVPA, ambulatory activities such as moderate to vigorous walking have been studied among peri- and postmenopausal populations. In order to examine the effect of moderate intensity walking on lumbar spine BMD, Yamazaki et al. (2004) conducted a controlled exercise trial on 50 postmenopausal women, ages 49 to 75 years, with osteopenia or OP. Baseline BMD was assessed via DXA, and each participant learned a walking speed and heart rate that corresponded with 50% VO_2max.

Women in the exercise group were instructed to walk for at least one hour with more than 8000 steps per day for at least four days per week over 12 months. Researchers found those in the exercise group increased their lumbar spine BMD by 0.47% at six months and 1.71% at twelve months. This was in contrast to the control group whose lumbar BMD decreased 0.45% and 1.92% at 6 and 12 months, respectively. These findings indicate moderate-intensity walking has a favorable effect on bone turnover of postmenopausal women with osteopenia or OP.

A similar study examined the effect of higher intensity walking on BMD of healthy postmenopausal women, ages 50 to 65 years (Borer et al., 2007). Baseline DXA assessments included BMD of the total body, hip, lumbar spine, radius and pelvis. Participant VO_2max was determined through a graded maximal treadmill test. Women in the exercise group participated in thirty weeks of supervised walking, 4.8 km per day, four days per week at 68-86% VO_2max. Age-matched controls also engaged in the same activity protocol, but did so at intensities less than 62% VO_2max. Researchers found that women participating in the higher-intensity training group increased total body and hip BMD by 0.4% and 0.8%, respectively, as compared to losses of 1.3% and 1.09% among low intensity controls. These findings provide further evidence of an association between ambulatory MVPA and BMD.

Some analyses suggest that BMD may increase in the hip or lumbar spine through a *variety* of ambulatory activities like brisk walking, jogging and stair-climbing. Heinonen et al. (1998) evaluated the effects of an 18-month endurance training program on the BMD of sedentary perimenopausal women, ages 52 to 53 years. Participants were assigned to an endurance training, calisthenics group, or control group. The endurance training consisted of intervals of walking, jogging, stair-climbing, and graded treadmill exercise at 55-75% of VO_2max performed three times per week. Researchers found hip BMD among the endurance group was significantly higher than controls (0.013 g/cm^2), while the calisthenics group saw no significant difference in BMD as compared to controls. Overall, the results show a combination of moderate-vigorous ambulatory activities is beneficial for femoral BMD among perimenopausal women, which is likely reflective of the variable strain distribution created by performing more than one activity.

Relationship between Muscular MVPA and Bone

The effect of muscular training, such as progressive resistance training or high-velocity/power training, on BMD is also the focus of research among postmenopausal populations. While results have mostly shown a positive effect of these forms of training on BMD, the effect of controlled velocity strength training has produced some conflicting results. For example, Nelson et al. (1994) conducted a one-year randomized trial where they examined the effects of high intensity strength training on BMD and strength among 39 postmenopausal women, ages 50 to 70 years. Those in the training group completed high intensity strength training twice weekly for one year, and the control group participated in no training. DXA scans showed BMD increased in the training group by 0.9% at the hip and 1.0% at the lumbar spine. BMD decreased in the controls by 2.5% at the hip and 1.8% at the lumbar spine. Total BMD was maintained in the training group and decreased 3.4% in the controls. These results indicate a high-intensity strength training regimen is beneficial for maintenance of BMD, and possibly for improving BMD among postmenopausal women.

The findings of Nichols and colleagues (1995) were in contrast to those reported by Nelson et al. (1994). Nichols et al. (1995) conducted a study to determine the efficacy of a high-intensity 12-month strength training regimen on the BMD of active older women. Participants were matched by level of physical activity, and randomly assigned to a weight training or control group. BMD of the spine, hip, and total body was assessed at baseline, six months, and twelve months. Results indicated an improvement in strength in the weight training group versus controls, but no improvement in BMD was found at any site in the training group versus the controls. This indicates high-intensity weight training may not improve BMD in older women who are already active, and the controlled velocity of movement may limit osteogenic responses. This potential shortcoming associated with slower velocity movements has lead researchers to examine the effects of power-based physical activity on bone.

Recent studies investigated the idea that high-velocity resistance training may be more beneficial for bone than controlled-velocity resistance training. For instance, Stengel and colleagues (2005) conducted a randomized controlled study comparing the effect of a twelve-month training program performed at a high-velocity versus a controlled-velocity among 53 healthy postmenopausal women. Researchers found the power training group maintained BMD at the lumbar spine (+0.7 g/cm^2) and hip (0.0 g/cm^2) as compared to losses in the strength training group at the spine (-0.9 g/cm^2) and hip (-1.2 g/cm^2). These findings suggest high-velocity training may be more effective than controlled-velocity training in maintaining BMD among postmenopausal women. This is likely due to the osteogenic, site-specific response elicited through the large, eccentric muscle pulling forces involved in such training (Stengel et al., 2005).

Relationship between Combinations of MVPA and Bone

Because a substantial body of evidence exists that indicates both ambulatory and muscular MVPA seem to be beneficial for bone, Kohrt and colleagues (1997) compared the effects of these two forms of training in an 11-month study of older adult females. The training programs included a *ground-reaction force group*, which included high-intensity ambulatory endurance activities like running and jumping, and a *joint-reaction force group*, which included resistance training and cycling. Both groups showed similar change in lumbar spine, hip and total body BMD, but hip BMD was higher in the ground-reaction force group. Overall, it was unclear which program was more effective, but the results substantiate the benefits of moderate to vigorous ambulatory and muscular training activities for bone health among sedentary older females

The positive effect of combined ambulatory and muscular MVPAs on bone was demonstrated through a 14-month controlled trial involving 137 osteopenic, postmenopausal women, which was conducted as part of the larger Erlangen Fitness Osteoporosis Prevention Study (Kemmler, et al., 2003). Participants were assigned to either an exercise or control group. Those assigned to the exercise group performed two 60-minute joint sessions and two 25-minute at-home sessions. Participants performed a variety of activities including running and aerobics at 70-85% of HRmax. Additionally, participants performed 3 to 5 sets of 15 to 20 repetitions of jump rope and multi-directional jumps, as well as progressive resistance training performed between 60-90% 1-RM. Following the intervention, researchers found an increase in lumbar spine BMD of 1.3% in the postmenopausal exercise group versus -1.2% in the controls (Kemmler et al., 2003). This provides a direct link for the positive effect of moderate-vigorous aerobic and muscular training exercises on BMD of postmenopausal women at high risk for OP.

Current Trends in Women's Physical Activity Behavior

Despite the beneficial effect of MVPA for bone strength and overall bone health, as well as the evidence of accelerated bone loss that occurs with *lack* of physical activity, less than half of all women participate in activity according to guidelines. For instance, according to the CDC's Behavioral Risk Factor Surveillance System ([BRFSS]; 2007), only 47% of all women meet physical activity guidelines for bone health. Additionally, BRFSS data show that 38.7% of all U.S. women report more than 10 minutes of activity per week, but they are not active enough to meet current guidelines (*insufficiently active*). An additional 14.3% perform less than 10 minutes of activity per week (*inactive*). Physical activity surveillance data (BRFSS, 2007) for the state of Iowa is worse than the national average. Reports indicate 42.4% of Iowa women are insufficiently active and an additional 11.2% are inactive**.** These data indicate that, in comparison to the national average, fewer Iowa women meet physical activity guidelines. This may place Iowa women at greater risk for diseases associated with an insufficiently active lifestyle.

In addition to the self-report data collected through surveillance research, Troiano et al. (2008) recently conducted an objective assessment of U.S. adult physical activity. Researchers assessed the physical activity levels of 6329 participants in the 2003-2004 National Health and Nutrition Examination Survey (NHANES). Objective physical activity was assessed with an accelerometer, worn by the participants for seven consecutive days. The accelerometer measures included counts per minute and time spent in physical activity at or above established count thresholds, which allowed researchers to estimate adherence to physical activity guidelines. When data were analyzed in bouts of ten minutes or more, results indicated that less than 5% of adults achieved thirty minutes or more of moderate physical activity at least five days per week. Additionally, on average, adults obtained less than two minutes per day of vigorous activity. While studies using objective monitors have limitations, such as the inability to detect upper body exercise or load carrying, these prevalence data are in stark contrast to the 47% prevalence based on self-reports of physical activity (BRFSS, 2007).

In a similar assessment of physical activity, Metzger et al. (2008) conducted an analysis of 2003-2004 NHANES data to examine accelerometer measured physical activity patterns of U.S. adults. Participants wore the accelerometer for seven days, and daily minutes of MVPA and VPA were determined, allowing them to be categorized by activity level. Findings showed 78.7% of the population was assigned to the least active classes, indicating less than 25 minutes of physical activity per day. Only 0.9% of the population fit into the most active group, where the average activity was 134 minutes per day. These data indicate a large portion of the population does not meet current physical activity guidelines, supporting previous surveillance data (BRFSS, 2007).

In the U.S., women's inactivity continues to increase with age, and in comparison to males, it does so to a greater degree. A cross-sectional investigation by Caspersen, Pereira, and Curren (2000) examined data from the National Health Interview Survey (NHIS) in order to report physical activity patterns by age and sex. Self-reported physical activity was analyzed in accordance with the Healthy People 2000 objectives among adults. Age groups included in the study were 18-29, 30-44, 45-64, 65-74, and 75+. Across the five age groups, adult women had a significantly higher prevalence of inactivity than men (average of 27% vs. 21%). Analysis by age group indicated that among women aged 45-64 and 65+, 13.9% and 26.0% were inactive, respectively. This may be contrasted to men where among those aged 45-64 and 65+, 13.7% and 20.7% were inactive, respectively. Additionally, this gap became more substantial around age 65 (9% difference) and continued to widen into the age 75+ age group (16% difference).

The lower prevalence of physical activity participation among middle-aged to older adult females is a concern for prevention of diseases that are associated with inadequate physical activity. Additionally, increasing prevalence in women's physical inactivity with age and in comparison to men is especially concerning when considering diseases that primarily affect women, such as OP.

Understanding and Promoting Physical Activity

Promotion of physical activity is imperative for reduction of OP risk among peri- and postmenopausal women. In order to promote physical activity for OP prevention, determinants of this behavior among peri- and postmenopausal women should be understood. Most research aimed at understanding and promoting physical activity for general health and OP prevention has focused on individual-level psychological determinants (Ali & Twibell, 1995; Estok et al., 2007; Godin & Kok, 1996; Haggar, Chatzisaratis, & Biddle, 2002; Hsieh, et al., 2001; Swaim et al., 2008). Research focusing on individual-level psychological determinants research has significantly contributed to the understanding of physical activity behaviors; however, a limited portion of the variance in these behaviors has been explained by cross-sectional research (Godin & Kok; Spence & Lee, 2002). Additionally, interventions based on these cross-sectional investigations have rendered only short-term changes rather than long-term results (Marcus & Forsyth, 1999).

The limited success of individual-level psychological approaches in explaining and promoting physical activity behavior has lead to the recognition that physical activity is likely influenced by factors that pertain to and extend beyond the individual. Consequently, this has prompted researchers to adopt multi-dimensional theoretical perspectives that permit examination of individual and environmental determinants of physical activity (Bandura, 1997; Spence & Lee, 2002). Using such a perspective for OP prevention could allow researchers to capture the complex, multi-faceted nature of physical activity behavior.

In addition, applying a multi-dimensional perspective to peri- and postmenopausal women might reflect the ways in which physical activity is influenced by the complex personal, social, and environmental issues facing these women (Elavskey & McAuley, 2005; Evantson, 2002; King, 2000; Thompson, 2002; WHO, 2009). For instance, personal changes that take place during menopausal transition may make physical activity participation especially difficult (Wing, Matthews, Kuller, Meilahn, & Platinga, 1995). For example, common physical and psychological menopausal symptoms include hot flashes, night sweats, insomnia, body composition changes, and mood swings (Hunter, 1990). Even though physical activity has been shown to decrease menopausal symptoms, among those experiencing symptoms (Blumenthal et al., 1991), decreased physical activity and an increased incidence of depressive symptoms and decreased perceptions of quality of life, physical self-worth, and well-being have been found (Bosworth et al., 2001). Additionally, menopausal women who are physically inactive may perceive worsening quality of life, which may, in turn, further decrease physical activity (Brown et al., 2003).

For example, the decrease in physical activity associated with menopausal symptoms was demonstrated in a recent study by Elavsky and McAuley (2005), who conducted a study to examine the relationships among physical activity, symptom reporting, self-esteem, and life satisfaction. Participants included 133 women, ages 44 to 60, with varying menopausal status. Menopausal symptoms, self-reported physical activity, global self-esteem, physical self-perceptions, and quality of life were also assessed. Analyses revealed that women who were more physically active had less severe general and somatic symptoms and reported higher levels of physical self-worth. Physical activity, symptoms, and physical self-worth explained 32% of the variance in satisfaction with life. Additionally, symptoms ($R^2 = 0.33$) and physical activity ($R^2 = 0.34$) were independent, significant predictors of physical self-worth. Results indicate that while being physically active may reduce the severity of menopausal symptoms and enhance psychological self-perceptions, low self-perceptions and menopausal symptoms may have the potential to reduce physical activity levels. These associations were in line with findings from an earlier study by Bosworth et al. (2001), who found emotional symptoms associated with menopause are related to physical inactivity in women.

In addition to the personal changes women are facing during menopause, environmental issues may compound these factors, making physical activity difficult. In terms of the social environment, women often have home and family care-giving responsibilities which could diminish their time and energy, decreasing their opportunities to participate in physical activity. Such personal and environmental barriers to physical activity were explored among 2912 women, ages 40 and over (King et al., 2000). Researchers used a survey based on the BRFSS and NHIS, which assessed physical activity levels, physical health, and psychosocial and environmental issues. Results indicated lack of time (OR = 0.95, 95% CI = 0.89-1.02), care giving duties (OR = 0.95, 95% CI = 0.90-1.01), and fatigue (OR = 0.92, 95% CI = 0.85-0.99) were the top three factors associated with low levels of physical activity. Similarly, Thompson et al. (2002) studied the social determinants of physical activity in women and found the primary barriers to physical activity were inadequate support for household and care giving responsibilities. Other barriers included difficulties balancing home and social expectations and low levels of support for physical activity from members of their community and workplace. Women also reported the importance of their family obligations served as a barrier to physical activity.

Broader environmental factors may also influence women's physical activity. For example, women's income tends to be lower than men's income, and women often do not control household resources. This could make access to physical activity facilities or home equipment a potential barrier. In order to investigate these issues, Evenson et al. (2002) conducted a focus group study among 49 middle-aged women. Researchers found many of the women depended heavily on their husbands for transportation and financial access to facilities. Because many husbands were not supportive of physical activity, these factors served as barriers to activity. Additionally, women cited the importance of the family, household care taking, and lack of time as other barriers to their activity.

Collectively, these studies underscore the complexity of the menopausal transition by highlighting the personal, social, and environmental issues facing these women. Such issues have the potential to negatively influence physical activity, further increasing women's risk for OP. These data emphasize the need to study physical activity behaviors of peri- and postmenopausal women in a multi-dimensional manner. The use of such a perspective may provide a greater understanding of the ways in which personal, social, and environmental factors influence physical activity directly and indirectly.

Social Cognitive Theory

Social Cognitive Theory (SCT) is one multi-dimensional approach that focuses on the individual as well as the broader social and physical environmental factors that have the potential to influence behavior (Bandura, 1997). SCT emphasizes the reciprocal interaction between the person, the behavior, and the environment, thereby offering three primary pathways by which physical activity in peri- and postmenopausal women may be more clearly understood. Few research studies use SCT to understand the influence of individual, perceived social, *and perceived physical environmental* factors on the physical activity of peri- and postmenopausal women. However, a review of existing literature focusing on each of these areas (individual, social, and environmental) in other adult female populations could provide support for such an analysis in the peri- and postmenopausal population.

Social Cognitive Determinants of Physical Activity

According to SCT, research aimed at understanding and promoting physical activity should focus on the individual, perceived social, and perceived physical environment (Bandura, 1997; Resnick et al., 2002). However, most research using social cognitive perspectives has focused on individual-level factors, without including an analysis of perceived environmental factors (Bandura, 2001; Dzewaltowski, 1994). An increasing body of literature has emerged that examines the social environment, but the perceived physical environment has received considerably less attention (Trost et al., 2002). This incomplete perspective is a shortcoming of much of the physical activity literature employing SCT, as it has limited understanding of the multi-dimensional nature of physical activity behavior (King et al., 2002). Examining individual-psychological, perceived social, *and* perceived physical environmental determinants could allow for a more comprehensive understanding of physical activity behavior (Bandura, 2004).

Individual Psychological Determinants

One core individual-level SCT determinant that has been consistently identified and supported in the physical activity literature is self-efficacy (Bandura, 1997). Two different types of self-efficacy exist, including task and barrier self-efficacy. Task self-efficacy deals with competence and ability of an individual to perform a certain behavior in specific situations. Barrier self-efficacy refers to one's confidence in drawing on those abilities in the face of obstacles. Self-efficacy may impact physical activity behavior directly, or it may influence physical activity indirectly by mediating or interacting with the perceived social or perceived physical environment (Blanchard et al., 2005; Resnick et al., 2002).

Self-efficacy has continually emerged as an important determinant of physical activity in the physical activity/general health literature (Castro et al., 1999; Dishman, Sallis & Orenstein, 1985; Trost et al., 2002). Further, self-efficacy has been specifically identified as an important determinant of physical activity performed for OP prevention among peri- and postmenopausal women. For instance, a study by Ali and Twibell (1995) was one of the first OP prevention studies that examined the association between physical activity and task self-efficacy among 100 postmenopausal women, aged 50 years and older. Researchers examined the relationships between physical activity and task self-efficacy for physical activity, along with perceived benefits, barriers, and health status. Physical activity was measured through self-report. Results showed a significant relationship ($r = 0.25$) between physical activity and task self-efficacy. Significant associations were also found between physical activity with health status and perceived benefits and barriers for exercise. This study indicates the importance of self-efficacy for physical activity performed for OP prevention. Similar findings were also found in a recent investigation by Estok, Sedlak, Doheny, and Hall (2007) who reported task self-efficacy for exercise was significantly related to weight bearing physical activity ($r = 0.41$). These studies emphasize the importance of task self-efficacy for performance of the type of physical activity (weight-bearing) that is important for bone health.

Swaim, Barner, and Brown (2008) further substantiated the association between task self-efficacy and physical activity among postmenopausal women. Researchers examined demographic modifying factors, calcium intake, OP task, self-efficacy, and OP beliefs among 187 postmenopausal women, 65 years of age and older. Participants had no known history of OP. Self-reported weight-bearing exercise was assessed through the Community Health Activities Model Program for Seniors (CHAMPS; Stewart et al., 2001). The analysis showed task self-efficacy for exercise was positively related to exercise behavior, where self-efficacy explained 13% of the variance in physical activity. Interestingly, self-efficacy for exercise was also associated with calcium intake. The researchers concluded that task self-efficacy is an important correlate of physical activity and calcium intake among postmenopausal women, adding support for the importance of task self-efficacy in relation to OP prevention.

Although most OP studies measure task self-efficacy, barrier self-efficacy is also associated with physical activity. For instance, one physical activity study involving older adults supported the association between barrier self-efficacy and exercise behavior (Resnick & Nigg, 2003). This descriptive study examined social support, stage of change for exercise, barrier self-efficacy, outcome expectations, fear of falling, and exercise activity among adults aged 65 years and older. Physical activity was assessed through verbal reports of activity performed according to ACSM guidelines and written physical activity logs. Researchers found that barrier self-efficacy was significantly associated with physical activity ($r = 0.78$). These findings support evidence that barrier self-efficacy influences older adult physical activity behavior.

The positive findings between physical activity and barrier self-efficacy found in cross-sectional investigations were supported by an intervention study that examined the influence of self-efficacy on exercise adherence among 103 community-dwelling older adults (Brassington et al., 2002). A twelve-month telephone counseling intervention was employed to promote exercise adherence among participants through barrier self-efficacy enhancement. Barrier self-efficacy for exercise was measured at 0, 6, and 12 months. Physical activity was assessed with quantifiable physical activity logs. Researchers reported significant associations between the changes in barrier self-efficacy and physical activity adherence during the seven to twelve-month time period ($r = 0.46$). These findings lend further evidence to the importance of enhancing barrier self-efficacy to promote positive physical activity behaviors among community-dwelling older adults.

Perceived Social Environment

In addition to the association between self-efficacy and physical activity, social environmental factors like social support are positively associated with physical activity. Social support may be broadly defined as "aid or assistance afforded through social relationships and interactions" (Heaney & Isreal, 2002, p.187). Current evidence indicates positively perceived social support is a relevant factor related to taking up and adhering to physical activity among both male and female adolescent, adult, and older adult populations (Dishman & Sallis, 1994; Levers-Landis et al., 2003; Sternfeld et al., 1999). However, the ways in which perceived social support influences physical activity seems to vary by age and gender. For instance, the importance of social support may be higher for middle-aged and older females than younger adult females (De Bourdeaudhuij & Sallis, 2002). Further, informational support and seeing others engage in activity seem to be important for both males and females, but for females, having friends or family exercise with them also appears to be important (De Bourdeaudhuij & Sallis, 2002).

Research indicates perceived social support may facilitate or inhibit physical activity directly, or it may influence physical activity indirectly through individual-level factors such as self-efficacy (Lewis, Marcus, Pate, & Dunn, 2002). The direct influence of social support on physical activity by age and gender was investigated by Eyler et al. (1999). Researchers assessed the relationship between physical activity and social support among U.S. minority women, aged 40 years and over. The Physical Activity Social Support Scale (PASS; Sallis, 1987) was used to assess friend and family general support. Questions regarding physical activity were in line with questions used for the U.S. BRFSS. As expected, researchers found those with low social support participated in lower levels of physical activity, and women reporting higher levels of social support from friends were more than two times as likely (OR = 2.07, 95% CI = 1.62-2.64) to participate in physical activity at *recommended levels* of frequency, intensity, and time (Eyler et al., 1999). Friend and family support had equally important associations with physical activity among these populations. This indicates perceived friend and family social support may be important for female physical activity participation, and it may even influence whether women meet the recommended levels of activity frequency, intensity, and time.

In addition to the direct association between perceived social support and physical activity, this relationship may be mediated by self-efficacy. For example, Resnick et al. (2002) tested the relationships among family, friend, and expert social support and physical activity among older adults, 65 years of age and older. Researchers used the PASS (Sallis, 1987) for assessing friend and family support, as well as support from experts such as trainers, physical therapists, nurse practitioners, and physicians. Participants were asked if they participated in 20 minutes of regular aerobic or resistance training exercise three times per week. Additionally, self-efficacy and outcome expectations were assessed. Findings indicated there was a significant association between friend support and self-efficacy ($r = 0.21$) and between self-efficacy and physical activity ($r = 0.66$). A path analysis also indicated friend support indirectly influenced physical activity through self-efficacy. These findings show that perceived social support, especially from friends, is important for older adults. Additionally, evidence indicates that both social support and self-efficacy are important for physical activity participation among older adults, in that self-efficacy may mediate the relationship between perceived social support and physical activity.

Not only are self-efficacy and social support both important for physical activity participation, they may also be associated with physical activity *domain*. Sternfeld et al. (1999) employed a cross-sectional investigation of demographic and psychosocial correlates of activity in the recreational, occupational, and household/care giving domains. Participants included 2636 ethnically diverse women, ages 20-65. Physical activity was assessed with the modified Baecke and KPAS questionnaires. Self-efficacy, perceived social support, and perceived barriers were investigated with questions included in the KPAS. Primary findings indicated the likelihood of high levels of sports and exercise participation was higher when the participants reported higher levels of perceived support (OR = 2.34, 95% CI = 1.83-2.98) and self-efficacy (OR = 3.96, 95% CI = 2.92-5.38). Interestingly social support was not significantly associated with a higher likelihood for being physically active in any one domain, and self-efficacy was associated with a decreased likelihood of being physically active in the occupational domain (OR = 0.77, 95% CI = 0.61-0.96). Overall findings indicate social support and self-efficacy may be most important for physical activity performed in the sport and exercise domain. This may underscore the importance of perceived social support and self-efficacy for activities that are discretionary and more vigorous in intensity, which may be important for prevention of diseases like OP.

The importance of social support and self-efficacy specifically for OP preventive behaviors was recently studied by Hseih, Wang, McCubbin, Zhang, and Inouye (2008). Investigators tested a model of factors influencing physical activity and calcium intake among 243 community-dwelling Taiwanese adults. They examined the association between OPBs and years of education, knowledge, self-efficacy, social support, and social capital. Physical activity was assessed through a 16-item Physical Activity Questionnaire ([PAQ]; Liu et al., 2001). Calcium intake was assessed using the Scale of Calcium Intake (Lin, 1999). Results indicated self-efficacy mediated the relationship between social support and exercise. Exercise self-efficacy and social support explained 25% of the variance in exercise. Interestingly, 46% of the variance in calcium intake was accounted for by social support and self-efficacy for exercise, indicating self-efficacy for exercise and calcium intake behaviors are related. Overall, this analysis indicates self-efficacy and social factors are important determinants of physical activity and calcium intake. Additionally self-efficacy may mediate the influence of perceived social support on physical activity and other related OP-preventive behaviors like calcium intake, which is similar to findings reported by Swaim et al. (2008).

The influence of perceived social support and self-efficacy on physical activity participation indicated by these cross-sectional investigations was substantiated by a recent longitudinal investigation (McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003). Researchers examined how well self-efficacy and social support predicted long-term exercise behavior in older adults following a six-month randomized controlled trial. Participants included 174 sedentary older adults, ages 60 to 75 years. Analyses were conducted to determine how well affective responses, exercise value, and social support predicted 6- and 18-month follow-up activity when mediated by self-efficacy. Results indicated significant associations between social support, affect, and exercise frequency with self-efficacy at 6 and 18 months. Self-efficacy was directly associated with 6- and

18-month physical activity. The entire model explained 40% of the variance in physical activity. Similar to cross-sectional investigations, self-efficacy mediated the associations between social support with physical activity (Hseih et al., 2008; Resnick et al., 2002), emphasizing the importance of both self-efficacy and perceived social support for physical activity.

Perceived Physical Environment

In addition to the personal and social determinants of physical activity, the perceived physical environment is shown to influence physical activity (Blanchard et al., 2005; Booth et al., 2000; Giles-Corti & Donovan, 2002). Unlike individual and some perceived social determinants of physical activity, the perceived physical environment has only recently begun to be investigated. While the literature supporting this construct is relatively limited, evidence for its use as a physical activity determinant is growing (King et al., 2002; Trost et al., 2002; Wendel-Vos et al., 2007).

Similar to social support, the perceived physical environment may exist in a way that enables or acts as a barrier to health behavior (Sallis & Owen, 2002). The *environment* refers to elements physically outside of the individual that may influence behavior, and this may be actual or perceived. However, the perceived environment seems to be more closely related to health behaviors like physical activity, which is in line with SCT, where the environment influences behavior through the cognitive processes of the individual (Kirtland et al., 2003). From the perspective of SCT, the environment may provide opportunities, resources, or cues to an individual that positively influence health behavior; especially when those opportunities, resources, or cues are perceived as convenient or accessible by the individual.

Access to recreational facilities and home equipment appear to be important determinants of physical activity among adolescents, adults, and older adults (Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Giles-Corti & Donovan, 2002). In one of the earliest studies of the physical environment and physical activity, Sallis et al. (1997) assessed environmental variables in homes, neighborhoods, and frequently traveled routes. The presence of equipment, programs, attractive surroundings, and barriers were assessed among 110 college students. Results indicated home equipment and convenient facilities were associated with physical activity. When socioeconomic status (SES) was controlled, home equipment was still significant. While this study did not pertain to middle-aged or older adults, it laid the groundwork for future studies involving adults.

For instance, the association between physical activity and walking was investigated by Brownson et al. (2000) in a study examining the relationships between attitudes, access to walking paths and indoor facilities, and walking behavior among adults. Participants included rural, Midwest, community-dwelling adults, ages 18 years and over. Investigators collected data through a telephone survey that was adapted from the BRFSS. Data regarding demographics, physical activity and walking levels, and access to walking trails or exercise facilities were collected. Results indicated that people reporting access to walking trails and exercise facilities were 1.3 times more likely (95% CI = 1.0-1.7) to walk on a regular basis in comparison to those who did not report having access. This association was slightly stronger for women versus men and for those with convenient access to those facilities versus inconvenient access. These findings were in line with those of Ball, Bauman, Leslie and Owen (2001), who found adults reporting lower levels of convenient access were 36% less likely (95% CI = 0.54-0.77) to walk regularly and those reporting moderate levels of convenient access were 16% less likely (95% CI = 0.71-1.00) to walk regularly. The results of these studies indicate access to convenient walking paths and exercise facilities is associated with higher levels of walking activity among adults, providing support for the importance of convenient access for weight-bearing, ambulatory physical activity.

Differences between men and women have also been detected in research studying the association between environmental determinants and walking activity (Humpel et al., 2004). Humpel et al. (2004) examined associations of perceived environmental characteristics with walking for specific purposes among men and women, aged 40 years and over. Environmental characteristics included perceived aesthetics, safety, accessibility, and weather. Self-reported physical activity and perceived environment were assessed through mailed questionnaires. Comparative gender analyses revealed that women reporting moderate and high levels of accessibility to facilities for walking were 3.51 times (95% CI = 1.64-9.15) and 2.61 times (95% CI = 0.97-6.97) more likely to walk for pleasure than those with low levels of access. However, this relationship was not found for men. Additionally, in comparison to women who indicated weather was an activity barrier, women who did not indicate weather was an influencing factor were 7.68 times (95% CI = 3.03-19.46) more likely to walk for exercise and 3.84 times (95% CI = 1.68-8.77) more likely to walk in their neighborhood. This indicates perceived weather and environmental access significantly influences walking activity in women. Because the access may not be as relevant for men, physical activity interventions targeting perceived environmental access factors should consider potential differences between men and women.

In addition to the direct association between the perceived environment and physical activity reported by the above-described studies, the indirect relationship between the environment and physical activity through self-efficacy was supported in a recent study by Cerin, Vandelanotte, Leslie, and Merom (2008). Cerin et al. (2008) employed a cross-sectional study to examine the relationship between self-efficacy, perceived access to convenient facilities, and perceived access to home equipment, with leisure time physical activity (LTPA). Participants included 2650 adults, ages 20 to 65 years. Researchers found self-efficacy, access to home equipment, and access to facilities were independently associated LTPA. Additionally, self-efficacy moderated the association between access and LTPA, where access had a small positive effect on individuals with low reported self-efficacy. The researchers concluded self-efficacy, perceived access to facilities, and perceived access to equipment are important correlates of physical activity that should be considered for physical activity interventions among adults.

Extending the combined importance of the individual and physical environment, the importance of the individual, perceived social environment, and perceived physical environment is also supported. For example, Booth and colleagues (2000) employed a social cognitive approach to understand individual, social, and perceived environmental influences on physical activity among older adults, ages 60 years and over. This study specifically assessed physical activity level; sociodemographic factors; attitudes, self-efficacy, social reinforcement and social modeling by friends or family; and physical environmental influences. Physical environmental factors included home physical activity equipment, facility access, and safety. Results showed self-efficacy, social support, safety, and access to facilities were significantly associated with physical activity behavior. Comparisons between active and inactive participants revealed that in comparison to inactive participants, a significantly greater proportion of active participants had higher self-efficacy (48% vs. 26.6%), higher social support (56% vs. 42.7%), higher perceived safety (85.5% vs. 75.3%), and greater access to convenient facilities (40.8% vs. 20.9%). These results indicate self-efficacy, social support, safety, and access to convenient facilities are important determinants of physical activity.

Although the individual, social and perceived environmental determinants of physical activity are supported in the literature, the relative importance of each of these factors may vary. In order to examine these issues, Giles-Corti and Donovan (2002) studied the relative influence of and interaction between the individual, social, and physical environmental determinants of recreational physical activity. Participants included 1803 healthy workers and home-makers, aged 18 to 59 years. In comparison to those reporting lower scores, findings showed those reporting higher scores for individual-level factors and social factors were 8.14 times (95% CI = 6.00-11.05) and 3.72 (95% CI = 2.76-4.98) times more likely to exercise according to recommendations. As for the physical environment, no significant associations were found, however, trends indicated those reporting greater access to facilities were 1.43 times (95% CI = 1.09-1.88) more likely to exercise according to recommendations. Overall, the findings indicate the importance of both individual and social factors for physical activity behavior, and the researchers indicated this may be further supported by a favorable physical environment (Giles-Corti & Donovan, 2002).

The findings of the above-described cross-sectional studies were substantiated through an intervention study by Brownson et al. (2005). Researchers employed a multi-level quasi-experimental study to promote walking in 12 rural Midwest communities. Interventions were applied at the individual, social, and community levels; and they aimed to improve walking and past week moderate physical activity. The intervention focused on enhancing self-efficacy, benefits, and overcoming barriers, and social support was targeted through exercising with others and through patient-health care provider relationship. Walking clubs were also formed based on community input in order to enhance social support opportunities. Analyses showed those communities with a high intervention dose and high access to facilities were more likely (OR = 4.63, 95% CI = 0.72-29.84) to meet walking recommendations than those in the high dose category with low access to facilities (OR = 2.25, 95% CI = 0.36-14.12). Researchers reported that participants with moderate to high intervention dose were more likely (OR = 2.88, 95% CI = 1.04-7.98) to meet guidelines for walking. Results demonstrate interventions targeting self-efficacy and social support may increase walking activity, and this may be further supported by perceived access to facilities. Researchers concluded that it may be helpful to target social support, access, *and* self-efficacy at the same time when aiming to enhance physical activity in adults (Blanchard et al., 2005).

Demographic Factors and Physical Activity

Several personal demographic variables are consistently associated with physical activity, including age, race, BMI, education, and income. For instance, Brownson et al (2000) examined correlates of physical activity behavior in women aged 40 years and older. Researchers found that age and BMI were indirectly associated with physical activity, and socioeconomic status and highest level of education achieved were directly associated with physical activity participation. These associations also have been supported in several other studies (King et al., 2000; Martinez-Gonzalez et al., 1999; Sternfeld et al., 2003). The consistent support these variables have seen in the literature in relation to physical activity substantiates the use of these variables as potential control variables in this study.

Measurement of Physical Activity

As illustrated by behavioral determinants studies reviewed, the evaluation of physical activity determinants is extremely complex and is, therefore, best served with multidimensional approaches. Additionally, similar to *determinants* of physical activity, *physical activity* is also a complex, multi-faceted behavioral outcome. Therefore, a multi-dimensional approach to physical activity measurement is also warranted.

Self-Report Measures

In epidemiologic research, measurement of physical activity generally relies upon self-report methods due to the large sample sizes involved, the low cost of the instrument, and ability to assess domain, context, or specific types of activity (Tudor-Locke & Myers, 2001). The ability of a measure to assess domain, context, or specific type of activity may be especially relevant for women's bone health. For instance women likely perform activity in one or more domains, including leisure, occupational, home, or transport domains (Greendale et al., 2002; 2003). Further, activities may be performed in particular contexts such as in neighborhood or group settings (Brownson et al., 2000). Lastly, certain types of mechanical loading activities important for bone health may be performed such as traditional weight training or Pilates, or family/home activities such as carrying children, carrying laundry up and down stairs, or gardening. These facets of physical activity may be relevant for bone health and can be captured with self-report measures. One self-report questionnaire that has been found to be a valid and reliable instrument, and that has been successfully implemented in research studies involving middle to older-aged women, is the Modifiable Physical Activity Questionnaire ([MAQ]; Kriska, 1992; Schulz, 1994).

The MAQ is used to evaluate the associations between physical activity levels and physiological measures, as well as to describe physical activity domains and patterns among middle-aged and older adult females. For example, a cross-sectional analysis was recently conducted to examine the association of physical activity on physiological components associated with metabolic syndrome in middle-aged to older women (Bertrais et al., 2005). Participants included 1932 women, ages 50 to 69. Physical activity was assessed with the past year MAQ in the leisure and occupational/ home domains, and the amount of MVPA was calculated. Researchers found those participating in recommended moderate to vigorous physical activity were less likely (OR = 0.34, 95% CI = 0.17-0.66) to have metabolic syndrome. This study indicates the MAQ was useful for detecting the amount of MVPA performed and compare to current public health guidelines. Additionally, this method allowed researchers to detect associations with physiological variables associated with poor health outcomes.

The MAQ is also useful for assessing physical activity among postmenopausal women at risk for OP. For instance, as part of the Women on the Move through Activity and Nutrition study, ([WOMAN]; Conroy et al., 2007) a cross-sectional analysis was conducted to evaluate which psychosocial factors were most strongly correlated with physical activity in 497 early postmenopausal women, ages 52 to 62. Additionally, these researchers investigated which factors were associated with lapses in physical activity and how the lapses impacted overall physical activity levels. Physical activity (MET-hrs/wk) was measured with the past week and past year MAQ. Objective past week physical activity was also assessed in a subgroup of 170 participants with the Accusplit pedometer. Participants were asked to report lapses in physical activity over the past six months. Psychosocial factors evaluated included exercise processes of change and decisional balance, barrier self-efficacy, and depression. Physical activity assessed through the MAQ was significantly associated with self-efficacy ($r = 0.31$), processes of change ($r = 0.31$), perceived benefits ($r = 0.22$), and better quality of life ($r = 0.16$). Through use of the MAQ, researchers were able to discern the association of physical activity participation and adherence with psychosocial variables, which are important determinants of physical activity behavior among postmenopausal women.

In another investigation of physical activity among postmenopausal women participating in the WOMAN study (Newman et al., 2009), researchers evaluated the month-to-month variation in physical activity levels of 508 women, ages 52 to 62 years. Women were randomized into a health intervention group or health education group. Physical activity was assessed with the past week and past year MAQ, and objective physical activity was assessed with the Accusplit pedometer at baseline and 18 months. At baseline, pedometer steps and past week MAQ data showed seasonal variation, with the highest steps and highest subjectively assessed activity (MET-hr/wk) in the summer months. Following the 18-month intervention, the lifestyle group significantly increased their physical activity levels, as measured objectively and with the past year MAQ. In comparison to the health education group, the lifestyle group took more steps (8499 steps/d vs. 6462 steps/d) and reported greater subjectively measured leisure activity (16.2 MET-hr/wk vs. 12.5 MET-hr/wk). The occupational/home activity was not substantial enough to include in the analysis. Using the MAQ allowed the researchers to assess volume and intensity of leisure physical activity among postmenopausal women. Additionally, the MAQ data supported pedometry data and provided evidence as to which domain this activity primarily took place.

While there is much support for the use of the MAQ and other similar self-report instruments, researchers must recognize their limitations. Limitations of self-report measures include issues associated with social desirability, misinterpretation and translation, conceptualization of physical activity performed and accumulated in various domains, and problems with recall (Tudor-Locke & Myers, 2001). Although the MAQ may detect activity and intensity of activity performed across different domains, women still may have difficulty recalling light and moderate physical activity performed in non-leisure domains. This makes it difficult to capture true patterns of physical activity among women, and to discern the importance of activity performed throughout the day. This may be especially problematic for women who, in their traditional roles, may perform much of their activity in caring for the home and family (Ainsworth, 2000).

Objective Measures

In order to help overcome some of the limitations of self-reported physical activity measures, objective measures of physical activity are typically utilized. The most accurate objective measures of activity include direct observation, indirect calorimetry, and doubly-labeled water. While these measures are proposed as potential gold-standards against which other methods may be compared, they are extremely costly and time-consuming for larger population-based studies (Dale et al., 2002). More recently, other forms of objective monitoring of physical activity have emerged, such as heart rate monitoring, pedometry, and accelerometry. The efficacy and feasibility of these measures allow researchers to quantify physical activity in a way that has not previously been possible with self-report (Corder, Brage, & Ekelund, 2007).

Accelerometers and pedometers can provide measures of activity volume, and accelerometers and *some* pedometers can assess intensity of activity. These devices are able to detect activity intensity, as well as activity people are not able to recall or that they may not think of as activity, like accumulated walking in a variety of domains and contexts. This is important because accumulated activity is central to many physical activity guidelines, and moderate to vigorous walking may be one of the most common forms of weight-bearing physical activity performed in the general population that could be beneficial for bone (Tudor-Lock & Myers, 2001).

While accelerometers are ideal due to their detailed time-stamping capabilities and the precise way in which they measure movement, they are more expensive than pedometers. However, more recently, a second generation of pedometers has become available that function like accelerometers in their ability to measure activity intensity. For studies involving measures of adult ambulatory activity, these more affordable instruments are sufficiently accurate in their ability to measure physical activity (Crouter, Schneider, & Bassett, 2005; Tudor-Locke, Williams, Reis, & Pluto, 2004). Additionally, due to their low cost, they are more feasible for large-scale studies or when resources are limited (Tudor-Locke & Meyers, 2001).

One second generation pedometer that has recently come into the market is the New Lifestyles NL-1000 pedometer (New Lifestyles Inc., Lees Summitt, MO). This specific pedometer model is a more updated, precise instrument than the older NL-2000 and SW-200 models. Due to the recent development of the NL-1000, research described here will emphasize the other NL instruments.

The NL-2000 (Crouter, Schneider, Karablut, & Bassett, 2003; Crouter, Schneider, & Bassett, 2005; Schneider, Crouter, & Bassett, 2003) and SW-200 (Swartz, Bassett, Moore, Thompson, & Strath, 2003) are supported as valid and reliable instruments for ambulatory physical activity monitoring. Although the NL-2000 is deemed to be more accurate than the SW-200 pedometer due to the accelerometer versus spring lever mechanism (Crouter et al., 2005), the NL pedometers are shown to be significantly correlated with each other over 24-hours of monitoring (Schneider, Crouter, & Bassett, 2004). Both the NL-2000 and SW-200 are successfully used in ambulatory physical activity research in middle-aged and older adult women.

For instance, Thompson, Rakow, and Perdue (2004) conducted a study to investigate the relationship between the pedometer measured physical activity, body composition, and BMI among middle-aged women. Eighty women, ages 40 to 66, were instructed to wear the SW-200 pedometer for seven days, and body fat percentage was measured. Participants were grouped by activity level, including inactive (< 6000 steps/day), somewhat active (6000-9999 steps/day), and active (≥ 10,000 steps/day). Results indicated a significant association between average steps per day and body fat percentage and BMI. By using pedometer-derived measures of physical activity, researchers were able categorize people by activity level and detect associations with important physiological measures associated with chronic disease in middle-aged to older women. These results were in line with those found in a similar study by Krumm, Dessieux, Andrews, and Thompson (2006), who successfully used the SW-200 pedometer to identify activity levels of postmenopausal women and detect associations with body composition.

Like the SW-200, the NL-2000 was used to detect the association between physical activity and body composition variables in middle-aged women (Hornbuckle, Bassett, & Thompson, 2005). Researchers evaluated percent body fat and seven-day physical activity with the NL-2000 and SW-200 among 69 African American women, ages 40 to 62 years. BMI, waist-to-hip ratio, and body fat percentage were assessed. Participants were categorized based on their physical activity levels, including sedentary (<5000 steps/day), low active (5000-7999 steps/day), somewhat active (7500-9999 steps/day), and active (≥10,000 steps/day). Results showed an inverse association between the activity and body fat percentage (r = -0.50), BMI (r = -0.47), and waist to hip ratio (r = -0.27). These findings indicate the NL-2000 is useful for categorizing physical activity and detecting associations between ambulatory activity and physiological variables known to influence health among middle-aged women.

In addition to the usefulness of pedometers in measuring physical activity and the associations with physiological measures, the NL-2000 is also used to examine the results of a walking intervention in middle-aged female populations. For example, Hultquist, Albright, and Thompson (2005) conducted an investigation of 73 sedentary, healthy females, ages 33 to 55 years. Researchers aimed to compare steps accumulated by women instructed to walk 10,000 steps per day (10K group) versus those told to take a

30-minute brisk walk. The 30-minute brisk walk is in line with current public health guidelines, however researchers have suggested 10,000 steps is comparable to this. Baseline physical activity was measured with the NL-2000 for fourteen days, and then participants were randomly assigned to either a 10K or 30 minute walking group for a four week intervention. Results indicated there was a significant difference in daily steps between groups during the intervention. The 30-minute group walked an average of 8270 steps/day in comparison to the 10K group who walked an average of 10,159 steps/day. Researchers concluded women instructed to walk 10K walked more steps than those told to take a 30-minute brisk walk. This has implications for the effect of current public health guidelines for physical activity, and it demonstrates the usefulness of the NL-2000 for detecting such issues in research aiming to enhance physical activity in women.

Physical activity research substantiates the use of the NL pedometers in measuring physical activity and detecting associations with other important variables in middle-aged and older women. However, like subjective measures, pedometers are not without limitations. Pedometer limitations include the inability to assess load-carrying, upper-extremity movement, water activity, and poor capture of non-ambulatory movement like biking (Dale et al., 2002). Further, these instruments may malfunction, they have lower compliance than self-report, and provide no information as to context (Dale et al., 2002). However, using these monitors in conjunction with valid and reliable self-report measures like the MAQ will serve to capture important components of physical activity for women's bone health. For this study, then, the use of the MAQ and NL-1000 was warranted. The NL-1000 will assess weight-bearing, ambulatory, MVPA, and MAQ can determine the domains in which the MVPA is performed. These factors are important in light of current research evidence indicating weight-bearing MVPA is important for bone health, and evidence indicating women may perform activity in more than one domain (Ainsworth, 2002). Therefore, the use of the NL-1000 and MAQ in this study aided in understanding physical activity behavior, particularly MVPA necessary for optimal bone health and prevention of OP among peri- and postmenopausal women.

Summary

OP is a debilitating disease with troubling individual, social, and economic costs (USDHHS, 2007). As such, prevention of OP for peri- and postmenopausal women who are at risk of the disease is critical. Understanding and promoting physical activity among peri- and postmenopausal women is key step in the prevention of OP. This requires an examination of physical activity determinants, upon which intervention studies may be developed and employed. Most adult physical activity determinants research has focused on individual-level psychological determinants, which has aided in our understanding of physical activity, but much unexplained variance remains (Godin & Kok, 1996; Spence & Lee, 2003). The amount of unexplained variance may be attributed to the multi-dimensional nature of physical activity behavior, such that it is likely influenced by individual, social, and physical environmental factors (Sallis & Owen, 2002). However, research examining the factors outside of the individual is relatively limited. Therefore, comprehensive evaluation of peri- and postmenopausal women's physical activity will require examination of individual factors as well as factors that exist outside the individual, such as the social and physical environment.

SCT provides a valuable framework where the reciprocal relationships between the person, behavior, and environment may be examined. Several determinants that fit into a social cognitive perspective and have been supported in the literature include task and barrier self-efficacy, social support, and access to facilities and home equipment (Chatzisarantis et al., 2002; Humpel et al., 2004; Trost et al., 2002; Wendel-Vos et al., 2007). A review of the middle-aged and older adult female literature, as well as postmenopausal literature, supports the use of these determinants in physical activity research for these populations (Blanchard et al., 2005; Estok et al., 2007; Hsieh et al., 2008; Swaim et al., 2008). However, no OP prevention studies exist that examine physical activity according to individual, social, *and* perceived physical environmental determinants of physical activity. For OP prevention among peri- and postmenopausal women, applying a broad SCT approach may not only provide a more comprehensive understanding of physical activity, but it could more accurately reflect the complex personal and social changes facing peri- and postmenopausal women.

In addition to the information SCT may provide on the determinants side, studying peri- and postmenopausal women's physical activity in an objective and subjective way could provide insight into the quantifiable weight-bearing MVPA performed by these groups of women, as well as the domains in which they perform their activity. This is relevant for the prevention of OP considering the positive association between weight-bearing MVPA and bone health (ACSM, 2004), as well as recent research indicating women may perform their activity across multiple domains (Ainsworth, 2002). A more comprehensive investigation of physical activity behavior in peri- and postmenopausal women will help to deepen the understanding of a behavior that is critical to prevention of OP in this population.

CHAPTER III

METHODOLOGY

The primary purpose of this study was to utilize Social Cognitive Theory (SCT) to understand and describe determinants of moderate to vigorous physical activity (MVPA) for osteoporosis (OP) prevention among peri- and postmenopausal women. Specifically, this study examined relationships between individual psychological, perceived social, and perceived physical environmental determinants with the MVPA of peri- and postmenopausal women.

The following discussion will focus on the research methodology for this study, including an overview of the design, as well as a description of participant selection, power analysis and calculation of sample size, research instruments, research procedures, and data analysis with respect to specified research aims.

Design

This study was cross-sectional and observational in design and was implemented to better understand individual, social and environmental factors associated with MVPA among peri- and postmenopausal women. This information may be used to design and implement interventions aimed at prevention of OP. Six independent variables included task self-efficacy, barrier self-efficacy, perceived social support from family, perceived social support from friends, perceived access to facilities, and perceived access to home equipment. Five dependent variables consisted of two objective and three subjective measures of physical activity. The objective measures include (1) steps per day and (2) minutes per day spent in MVPA. Subjective measures included (1) past year MVPA, (2) past week leisure MVPA, and (3) past week occupational/transport MVPA. Figure 2 shows the operationalization of SCT constructs used in this study as well as the type of physical activity measured. Solid lines represent hypothesized direct associations and dotted lines represent hypothesized indirect relationships (moderated or mediated associations).

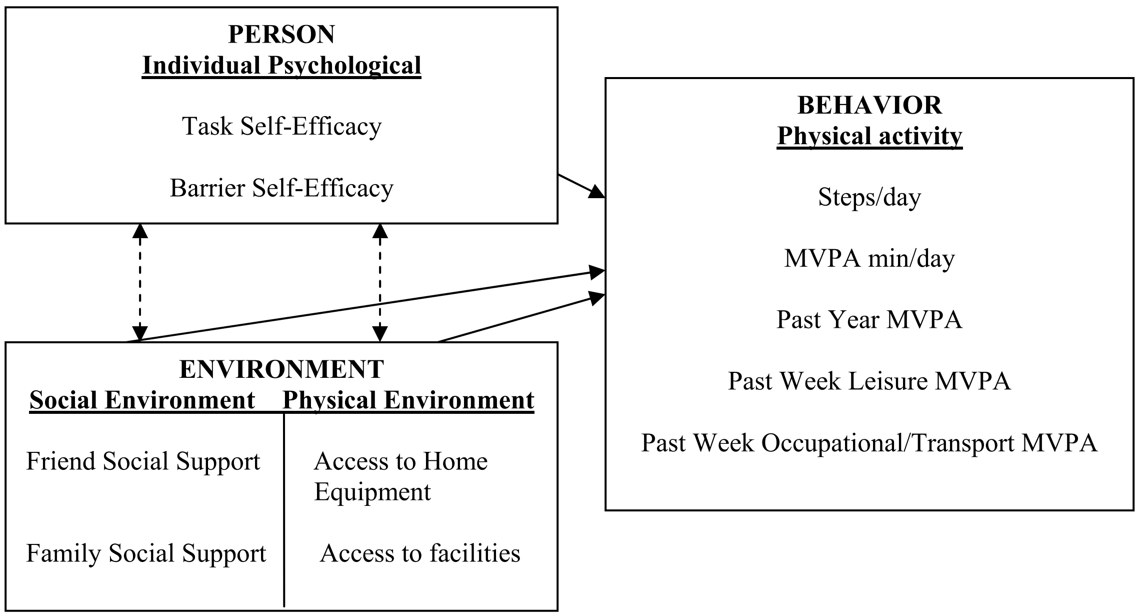

Figure 2. Operationalization of Social Cognitive and Physical Activity Study Variables.

MVPA = Moderate to Vigorous Physical Activity

Participants

Participants recruited for this study included 90 healthy peri- and postmenopausal women, ages 43 to 65 years. Women were recruited in person, by phone, through word of mouth, and via e-mail from a variety of organizations throughout rural and urban communities in eastern Iowa and western Illinois. These organizations included churches, private businesses, fitness and recreation facilities, colleges and universities, and local hospitals/health clinics. Women were also recruited by mail though the University of Iowa STAR registry.

Selection criteria included women of peri- or postmenopausal status who were no younger than age 43 and no older than age 65 at the time of data collection. Peri-menopausal women were classified as those who have experienced an alteration in menstruation due to a decline in ovarian follicular activity. This included irregular cycles or cessation of menstruation for less than one year (WHO, 1996). Postmenopausal women were classified as those who had experienced complete cessation of menstruation for one year or more due to ovarian follicular inactivity (WHO, 1996). The primary aims of this study involved grouping peri- and postmenopausal women together in order to understand behavior patterns of middle-aged women who are experiencing losses in estrogen.

Exclusion criteria included known hip or lumbar spine fragility fracture or diagnosed OP, and inability to perform regular weight-bearing ambulatory activity without the use of an external assistive device. Additionally, women taking anticonvulsant medications, glucocorticoids, those with diabetic neuropathy, or those with a previous clinical diagnosis of disordered eating were excluded from the study, as these factors have been shown to negatively affect bone health. In regard to the first exclusion criterion, it has been proposed that personal fragility fractures or personal knowledge (as opposed to general knowledge) of OP may alter physical activity behavior (Sedlak et al., 2007). The ambulatory activity criterion was established because objective physical activity monitors primarily assess ambulatory activity; therefore, they are not an ideal instrument for measuring activities like arm-cranking, wheel-chair propulsion, or walking with the use of an external assistive device (Melanson et al., 2004).

Power Analysis and Sample Size

Power of a statistical test refers to the probability of rejecting a false null hypothesis, or finding a difference or relationship that does exist. In other words, statistical power (1-β) refers to the likelihood the test will not lead to Type II error or a false negative (β) conclusion. In general, greater power increases the chances of being correct, but because power is associated with sample size, statistical significance, and effect size, greater power generally requires more participants and resources. Therefore, power of 0.80 is considered to be an adequate and acceptable standard used in the behavioral and health sciences (Graviter & Wallnau, 2005).

When desired power is established and sample size is unknown, the necessary sample size may be determined by specifying the appropriate level of significance and the estimated effect size. The level of significance (α) is established in order to minimize the chance of a Type I error, or the probability of declaring a difference or relationship exists when it really does not exist. In the behavioral sciences**,** $\alpha = 0.05$ is considered an acceptable level of significance. Effect size (f^2) refers to the strength of the relationship and is related to the coefficient of determination (R^2) in the case of a linear regression model. According to Cohen, Cohen, West, & Aiken (2003, p.179) a population $R^2 = 0.02$ or $f^2 = 0.02$ is considered a small effect size, a population $R^2 = 0.13$ or $f^2 = 0.15$ is considered a medium effect size, and a population $R^2 = 0.26$ or $f^2 = 0.35$ is considered a large effect size. In addition to this information, effect size may be estimated by examining R^2 values reported in relevant literature. Examination of the physical activity determinants literature where similar variables were reported as those used in this study reveals R^2 values ranging from 0.10 to 0.40, with most predictors having associated R^2 values of 0.10 to 0.20 (Ball et al., 2001; Estok et al., 2007; Hseih et al., 2008). According to Cohen et al. (2003), R^2 values of 0.10 to 0.20 would be considered moderate effect size. Therefore, a moderate effect size of 0.15 was deemed conservative and appropriate for this study. Sample size was calculated using Cohen's (2003) method for determination of sample size (n), where $n = [(L/f^2) + u + 1]$. In this study, Lambda (L) is an index related to population effect size (f^2), and u is the number of independent variables. L was derived from Cohen's L table for determination of sample size where the following established values were used: power = 0.80; error df $v_2 = 120$; $\alpha = 0.05$; and u = 6 independent variables (Cohen, 1983, p.477). Using this information, Cohen's tables for determination of sample size indicates L = 14.3. An effect size (f^2) may be calculated by the formula $f^2 = R^2/ (1- R^2)$. In this study, $f^2 = (0.15/0.85) = 0.176$. Using this information and the formula $n = [(L/f^2) + u + 1]$, $N = [(14.3/0.176) + 6 + 1] = 86$. In order to account for potential participant attrition, up to 90 participants were recruited for this study.

Research Measures

Several research measures were utilized in this study. A participant descriptive assessment included self-reported demographic information (including age, BMI, annual household income, and highest level of education), anthropometric characteristics, and calcium/vitamin D intakes. A calcaneal ultrasound was used to provide descriptive measures of bone status. Social cognitive determinants were evaluated through questionnaires, and physical activity was assessed through objective monitor and subjective interview.

Demographic and Anthropometric Assessment

Demographic and anthropometric data were assessed through self-report questionnaire (Appendix A). The content validity of this questionnaire was reviewed and confirmed by an expert in the field of women's endocrinology. This instrument assessed self-reported age (yr) and height (in). In addition, this instrument categorically assessed race, marital status, number of children, highest level of education completed, annual household income, smoking status, weekly alcohol consumption, menopausal status, hysterectomy, use of estrogen, use of corticosteroids, diagnosis of other co-morbidities, and family history of OP. Weight was measured with a standard calibrated floor scale. BMI (kg/m^2) was calculated by the researcher based on height and weight information with the formula [weight (kg)/height (m^2)].

Calcium and Vitamin D Intakes

The brief 18-item Block Calcium/Vitamin D Screener was used to assess participant calcium (mg) and vitamin D (IU) intakes ([Appendix B]; Cummings, Block, McHenry, & Baron, 1987). This instrument is based on the top fifteen foods and primary supplements (i.e., multivitamins) that contribute the greatest portion of dietary calcium among middle-aged to older women (Block et al., 1985; Cummings et al., 1987). The calcium/vitamin D screener uses a food-frequency method to assess current intakes. Frequency responses ranged from *never*, to *two to three times per month*, to *every day* for foods and beverages (Cummings et al., 1987). For some food and beverage items, participants were asked to indicate portions consumed (small, medium, and large) on the days they consume that particular food or beverage (Cummings et al., 1987). Calcium and vitamin D intakes were derived by multiplying the portion sizes (x0.5, x1.0, x1.5 for small, medium, and large, respectively) by frequency and nutrient data published by the USDA.

This screener was originally developed for the NHANES 1999-2001 survey period (Block et al., 1985). It has been validated in community dwelling middle-aged to older women, where it was found to correlate well with seven-day food records ([r=0.76]; Cummings et al., 1987). These researchers indicated this scale is suitable for studies of calcium and vitamin D intake in middle-aged to older women. For this study average daily calcium (mg/day) and vitamin D (IU/day) were used as descriptive variables, as calcium and vitamin D supplementation has been shown to positively influence bone in middle-aged and postmenopausal females (Cummings, 1990; Kukuljan et al., 2008; Prince et al., 2006).

Calcaneal Quantitative Ultrasound

A measure of calcaneal bone stiffness was obtained through Quantitative Ultrasound (QUS) using the Sahara Clinical Bone Sonometer (Hologic, Inc., Watham MD, USA). This information was used in this study for descriptive purposes and for subject participation incentive. The Sahara measures speed of sound (SOS, m/s) and broadband ultrasonic attenuation (BUA, Db/MHz) of an ultrasound beam passing through the heel. This provides a measure of bone stiffness (quantitative ultrasound index [QUI]) and an estimate of heel BMD (Hologic, 1998). QUS has been supported as a valuable screening tool for individuals performing ambulatory activity for exercise, as this type of activity generates compressive loading that would be directed through the heel to the lower extremity. For instance, steps per day have been significantly associated with SOS (r = 0.26) and bone stiffness (r = 0.25) among postmenopausal women (Kitagawa & Nakahara, 2008). Heel ultrasound measures have also been correlated with DXA measured BMD at the heel (r=0.82-0.86), hip (r = 0.41), lumbar spine (r = 0.33) and total body (r = 0.51) in postmenopausal women (Faulker et al., 1994; Hans et al., 1995).

Prior to participant testing, the QUS was calibrated according to standardized procedures for quality control (Hologic, 1998). While this is an automated procedure, it involved scanning a phantom model of known BUA prior to each testing session. The participant was debriefed about the QUS procedure and given an opportunity to ask questions. The QUS was then initialized and prepared with transducer gel according to specifications (Hologic, 1998). Each side of the participant's non-dominant heel was cleaned with a moist towelette. The foot was placed into the foot well, the positioning brace was secured to the leg, and then the measurement was taken. The Quantitative Ultrasound Index (QUI) and estimated BMD (g/cm^2) outcome measures were printed and recorded by the researcher (Appendix C). Each woman was provided with her results following participation in this study, along with an OP informational brochure.

Social Cognitive Constructs

Social cognitive constructs were examined through a questionnaire of combined instruments that assess task self-efficacy, barrier self-efficacy, social support from family and friends, and perceived access to facilities and home equipment (Appendix D). All instruments have demonstrated acceptable to strong reliability and internal consistency. A summary of independent variables may be found in Table 1. Psychometric properties of the instruments used for each of these variables may be found in Table 2.

Table 1. Source and Scoring Description of Social Cognitive Independent Variables.

Social Cognitive Factor	Independent Variable	Source	Scoring
Individual			
	Task Self-Efficacy	Osteoporosis Self-Efficacy Scale (Horan, 1988)	10 items, 10 cm visual analog scale Arithmetic mean
	Barrier Self-Efficacy	Exercise Self-Efficacy Scale (Marcus et al., 1992)	18 items, 5-point scale Arithmetic mean
Social			
	Social Support from Family	Social Support and Exercise Survey (Sallis, 1987)	13-items, 6-point scale Sum of scores
	Social support from Friends	Social Support and Exercise Survey (Sallis, 1987)	13-items, 6-point scale Sum of scores
Environment			
	Perceived Access to Facilities	Convenient Facilities Scale (Sallis, 1997; 2000)	17 items, yes/no scale Sum of yes items
	Perceived Access to Home Equipment	Home Equipment Scale (Sallis, 1997; 2000)	13 items, yes/no scale Sum of yes items

Table 2. Psychometric Properties of Social Cognitive Variables.

Social Cognitive Variables	Cronbach's α	Test-Retest Reliability	Participants	Test-Retest Timeframe	Source
Individual					
Task Self-Efficacy	0.94	--	201 women ages 35-95 yr	--	Horan et al., 1998
	--	r = 0.83	203 women ages 50-65 yr	0, 6, & 12 month	Sedlak et al., 2007
Barrier Self-Efficacy	0.77- 0.87	--	1063 men and women ages 30-60 yr	--	Marcus et al. 1992
Social					
Social Support from Family	0.90	r = 0.79	171 men and women ages 29-45 yr	2 week	Sallis et al., 1987
Social support from Friends	0.91	r = 0.79	171 men and women ages 29-45 yr	2 week	Sallis et al., 1987
Environment					
Perceived Access to Facilities	0.72	r = 0.80	110 college students ages 18-23 yr	1 week	Sallis et al., 1997
Perceived Access to Home Equipment	0.72	r = 0.80	110 college students ages 18-23 yr	1 week	Sallis et al., 1997

Task self-efficacy. Task self-efficacy was assessed by means of the Osteoporosis Self-Efficacy Scale ([OSES]; Horan, 1998). This scale was developed to assess confidence in the ability to perform activities necessary to prevent OP. This instrument includes items that assess physical activity and items that assess calcium intake. Only the items that assess physical activity were used for this study. The measure uses a visual analog scale and participants were asked to rate their response to each item by placing an "X" on the scale. The lower anchor of the visual analog scale read *not at all confident* and the upper anchor read *very confident*. Each item was based on the stem "if it were recommended you do the following this week, how confident would you be that you could…," and a sample item read "exercise three times per week."

Barrier self-efficacy. Barrier self-efficacy was assessed by means of the Exercise Self-Efficacy Scale (ESES) developed by the Cancer Prevention Research Center ([CPRC] Prochaska, 1991) that is based on a self-efficacy scale developed by Marcus, Selby, Niarur & Rossi (1992). This questionnaire was consistent with the recommendation put forth by Bandura (2006) for self-efficacy scale development in that it was developed specifically for exercise, was phrased in terms of capabilities versus intentions, and identified different types of challenges or barriers for exercise performance. This measure consisted of a 5-point scale where participants were asked to rate the efficacy for exercise in the face of possible barriers. Responses ranged from *not confident at all* to *completely confident*. Possible barriers for exercise assessed in this instrument included negative affect, excuse making, must exercise alone, inconvenient to exercise, resistance from others, and bad weather.

Social support from family and friends. Social support from family and friends was assessed by means of the Social Support and Exercise Survey ([SSES]; Sallis et al., 1987), which was designed to assess the frequency of support received from family or friends over the past 3 months. Items were based on the stem "during the last 3 months, how frequently has your family or member of your household…", and sample items read "…exercised with you" and "…gave you encouragement to stick with your exercise program." These same items were repeated but with the word friends replacing family. This instrument used a 6-point scale, ranging from 1 (never) to 5 (very often) and 8 (does not apply).

Perceived access to facilities and home equipment. Perceived access to facilities commonly seen in neighborhoods was evaluated according to those consistently reported in the literature (Sallis 1997, 2002). Participants were asked to answer *yes* or *no* to perceived convenient access to facilities commonly found in communities. It was explicitly stated that *convenient* referred to those facilities that were either on a frequently traveled route, within a 5-minute drive, or within a10-minute walk from home or work.

Perceived access to home equipment was measured similarly to facility access. Access to or availability of physical activity equipment or resources commonly found in the home were assessed (Sallis, 1997, 2002). This questionnaire was slightly modified to reflect new fitness innovations and technologies to which women may have access. For instance, stability balls, Bosu® balls were added to as examples for the toning devices item. Wii Fit®, DVD's, and other computer-based active play programs were added as examples to the workout videos item. Participants were asked to respond *yes* or *no* to the presence of equipment.

Objective Physical Activity Assessment

Objective physical activity was assessed with the NL-1000 pedometer (New Lifestyles, Inc., Lees Summit, Missouri). The NL-1000 measures steps and provides a limited measure of activity intensity. The internal timing mechanism resets the pedometer each day, allowing steps and activity minutes to be measured and stored for each day of wear. The NL-1000 pedometer houses a piezoelectric accelerometer mechanism with a ceramic strain-gauge beam. When acceleration takes place, the ceramic beam bends and compresses a piezoelectric crystal that generates a voltage proportional to the instantaneous vertical acceleration. These voltage oscillations are plotted as a sinusoidal curve against time (Schneider et al., 2004). When the oscillation reaches a manufacturer prescribed amplitude between 0.35 and 0.50 g, a step is counted. The number of times the sinusoidal curve crosses zero is counted and stored as number of steps per day ([steps/day]; Schneider et al., 2004). To estimate MVPA, the sinusoidal wave is analyzed every four seconds (4s) by the unit; when the number of steps in the 4s sampling interval reaches an intensity threshold that corresponds to a pre-established MET-level (≥ 3.6 METS for MVPA), those 4s are stored as activity time spent at or above 3.6 METS (New Lifestyles NL-1000 Users Guide, 2005). Approximately 8 to 8.5 steps per 4s (or 120-130 steps per minute) will trigger storage of the activity as MVPA time. Thus, the NL-1000 assesses the amount of time spent at MVPA levels, which is relevant considering current MVPA recommendations for bone health (ACSM, 2004).

The NL-1000 has been shown to be more accurate than other pedometers at slower walking speeds, and it is less affected by potential sources of error such as monitor tilt, wearer waist circumference, or wearer BMI (Crouter, Schneider, & Bassett, 2005). When the NL was compared to a Yamax criterion pedometer, the mean steady-state treadmill step values yielded by the NL were significantly associated with the criterion (Schneider et al., 2004). The validity of the NL has been further supported in both controlled and field environments. For example, Crouter et al. (2003) found the NL to be valid in comparison to a manual (hand) step counter at varied treadmill speeds. In comparison to manual step counting, the NL was shown to detect steps within 10% and 1% of actual when participants walked at speeds of 54 m/min and 64 m/min, respectively (Crouter et al., 2003). The NL has also been shown to detect steps within ± 3% of actual steps taken at self-selected walking speeds on a 400-meter track (Schneider et al., 2003). Finally, very strong intraclass correlation coefficients (ICC = 0.99) have been reported for the NL when worn on the right and left side of the body, demonstrating the intra-instrument reliability (Crouter et al., 2003; Schneider et al., 2003).

For this study, the NL-1000 was initiated for each participant by first setting the internal clock mechanism. The NL-1000 was then set to real-time display mode where it was ready to record total steps and activity minutes occurring at or above a 3.6-MET intensity. This setting provided an objective assessment of weight-bearing, ambulatory MVPA performed. For optimal accuracy, the monitor was placed on the waistband, belt, or a horizontal pocket; anatomically, this was between the iliac crest and umbilicus. Participants were asked to wear the sealed monitor for seven consecutive days. The NL-1000 stored data in 1-day epochs, and automatically set itself to zero at midnight of each day (New Lifestyles NL-1000 User Guide, 2005). This storage/reset characteristic was beneficial for this study because it allowed the pedometer to be sealed to minimize participant reactivity. On the sixth or seventh day of wear, the participant was contacted and asked to open the monitor and read their activity data from the monitor. The outcome measures for this study included average steps per day (steps/day) and minutes per day spent in MVPA (MVPA-min/day). A summary and description of the objective physical activity variables may be found in Table 3.

Subjective Physical Activity Assessment

Subjective physical activity was assessed through the Modifiable Activity Questionnaire ([MAQ] Kriska & Bennet, 1990). The MAQ is an interviewer-administered instrument that assesses current leisure and occupational/transport physical activity performed over the past year and past week. It has been shown to have moderately strong to strong test-retest reliability among middle-aged to older women ([r = 0.77-0.88]; Kriska et al., 1990). Moderate to strong validity has also been reported for this instrument with Actigraph accelerometer ([r = 0.43-0.60]; Petee et al., 2009) and doubly labeled water ([r = 0.56-0.88] Schulz et al., 1994). A summary and description of the past year and past week subjective physical activity variables may be found in Table 3. Psychometric properties of these instruments may be found in Table 4. The complete past year and past week instruments and scoring instructions can be found in Appendix E.

Past year. Past year physical activity was assessed through use of the past year portion of the MAQ. This instrument breaks down the assessment by leisure and occupation/transport domains. This allowed for data to be analyzed by domain or summed for total activity performed across all domains.

For the leisure activity component, the interviewer read from a list of activities commonly performed in the target population and "identify activities the participant performed on ten different occasions over the past year" (Kriska, 1997, p.S76). The activities identified were written down, and the participant was asked to estimate the months in which each activity was performed over the past twelve months (mo/yr), the frequency the activity was performed each month (freq/mo), and the average duration of activity performance each time the activity was performed (min/session).

For assessment of occupational and transport activity, the participant was asked to identify jobs held (for at least one month) over the past twelve months, and the number of months she was employed in that job (mo/yr). Occupations such as homemaker, retired, or unemployed were used when no jobs outside the home were identified. The participant was asked to identify the number of weeks worked per month (wk/mo), days worked per week (days/wk), and hours worked per day (hr/day). Participants were asked to estimate the average number of hours per day (hr/day) spent sitting at work, and then to describe the strenuousness of job activities performed when not sitting. For each job the participant was asked to describe usual activity to and from work and minutes per day (min/day) spent in transport to the job.

Hours per week for the leisure and occupation/transport activities were weighted according to the MET value for each activity, resulting in MET-hrs per week. MET values were derived from the Compendium of Physical Activity (Ainsworth, 2000). The outcome variable of interest for this measure was average past year (YRMV-MET-hrs/wk) moderate to vigorous activity (≥ 3.0 METS).

Past week. Past week physical activity was assessed through phone interview with the past week portion of the MAQ. Phone administration of this instrument was deemed appropriate by experts in MAQ administration. Similar to the past year version, this instrument breaks down the assessment by leisure and occupation/transport domains.

This allowed for data to be analyzed by domain or summed for total activity performed across all domains.

For the leisure activity component, the interviewer read from a list of activities commonly performed in the target population and placed a checkmark near activities the participant performed during the past week for at least ten minutes at a time. The participant was asked to estimate the days the activity was performed that week (days/wk) and minutes spent doing the activity each day (min/day).

For assessment of occupational/transport activity, the participant was asked to identify their current job held. Occupations such as homemaker, retired, or unemployed were used when no jobs outside the home were identified. The participant was then asked to identify the number of days worked in the past week (days/wk) and number of hours worked per day (hr/day). The participant was asked to estimate the average hours per day (hr/day) spent sitting at work. Finally, the participant was asked to describe activity to and from work and minutes per day (min/day) spent in transport to and from the job during the past week.

Hours spent in leisure and occupational/transport activities over the past week were then weighted according to the MET value for each activity, resulting in MET-hrs per week. MET values were derived from the Compendium of Physical Activity (Ainsworth, 2000). The outcome variables of interest were past week leisure (LMV-MET-hrs/wk) and past week occupation/transport (OMV-MET-hrs/wk) moderate-vigorous activity ($\geq$ 3.0 METS). These variables were used to describe the domains across which women perform their activity.

Table 3. Label, Description, and Source of Physical Activity Study Variables.

Physical Activity	Dependent Variable	Description	Source
Objective			
Total Steps	Steps/day	Average total steps taken per day	NL-1000 daily step counts
MVPA Minutes	MVPA-min/day	Average minutes per day spent in MVPA (≥ 3.6METS)	NL-1000 daily activity minutes
Subjective			
Past Yr MVPA	YRMV-MET-hrs/wk	Average MET-hrs per week spent in MVPA (≥ 3.0 MET) over the past year	Past Year MAQ (Kriska, 1990)
Subjective			
Past Wk Leisure MVPA	LMV-MET-hrs/wk	MET-hrs spent in leisure MVPA (≥ 3.0 METS) over the past week	Past Week MAQ (Kriska, 1990)
Past Wk Occupational MVPA	OMV-MET-hrs/wk	MET-hrs spent in occupation/ transport MVPA (≥ 3.0 METS) over the past week	Past Week MAQ (Kriska, 1990)

MAQ = Modifiable Physical Activity Questionnaire; MVPA = Moderate to Vigorous Physical Activity; Steps/day = Steps per Day; MVPA-min/day = MVPA Minutes per Day; LMV-MET-hr/wk = Past Week Leisure MVPA; OMV-MET-hr/wk = Occupational/Transport MVPA; YR-MV-MET-hr/wk = Past Year MVPA.

Table 4. Psychometric Properties of Past Year MAQ and Past Week MAQ.

Subjective Physical Activity Instrument	**Criterion**	**Validity**	**Reliability**	**Participants**	**Test-Retest Timeframe**	**Reference**
Past Year MAQ	Caltrac Accelerometer (counts/hr)	r = 0.41-0.69	--	17 Pima Indian men and women ages 37-59 yr	--	Kriska et al., 1990
Past Year MAQ		--	r = 0.63-0.88	69 Pima Indian men and women ages 21-36 yr	1 & 3 week	Kriska et al., 1990
Past Year MAQ	DLW	r = 0.56-0.88	--	18 Pima Indian men and women mean age 35 & 31 yr	--	Schulz et al., 1994
Past Year MAQ	DLW	r = 0.73	--	8 Pima Indian women mean age 31 yr	--	Schulz et al., 1994
Past Week MAQ	Caltrac Accelerometer (counts/hr)	r = 0.53-0.80	r = 0.77	17 Pima Indian men and women ages 37-59 yr	1 & 3 week	Kriska et al., 1990
Past Week MAQ	Actigraph Acclerometer (counts/day)	r = 0.53-0.60	r = 0.74	66 postmenopausal women ages 45-65 yr	1 week	Petee et al., 2009 in press
	Actigraph Acclerometer (MVPA min/day)	r = 0.43-0.60				

DLW = Doubly Labeled Water; MAQ = Modifiable Physical Activity Questionnaire; MVPA = Moderate to Vigorous Physical Activity

Procedures

All procedures were approved by the University of Iowa Committee for the Protection of Human Subjects (Appendix F). Participants were recruited in person, by phone, mail, or by email from a variety of organizations, as noted in the participant selection section of this paper. Interested participants were contacted either by phone or in person and verbally screened for eligibility according to the inclusion/exclusion criteria. A checklist was used by the researcher during the telephone screening to enhance consistency and minimize possible misclassification errors (Appendix G). If participants met the criteria for inclusion, they were debriefed about the study, and if they agreed to participate, a face-to-face data collection meeting was scheduled. All data were collected during one face-to-face contact and one follow-up phone contact.

During the scheduled face-to-face meeting, participants were presented with and asked to complete the approved informed consent forms; demographic, anthropometric, and health information was gathered; and calcium/vitamin D and the calcaneal ultrasound was measured. During this time participants were also asked to complete all social cognitive instruments, and the MAQ past year physical activity interview was conducted. At the end of this first meeting, each volunteer was provided with a programmed and sealed NL-1000; verbal and written/photo instructions for monitor placement and wear; an activity monitor on and off log (Appendix H); and an addressed, postage paid return envelope.

Participants were asked to wear the monitor for seven consecutive days and shown how to place the monitor on their belt or waistband. They were told it should be located between their hip and navel. Participants were instructed to wear the monitor at all times, except when sleeping or showering. They were also asked to log monitor on and off times on the provided activity monitor log. An activity monitor start day was agreed upon, which was typically the day following the first meeting. Participants were notified they would receive a follow-up phone call for monitor return and physical activity interview on the sixth or seventh day of wear. Times and phone numbers for these reminder and follow-up calls were agreed upon by the participant and researcher. Estimated time for completion of this first meeting was ninety minutes. The questionnaires and interviews lasted approximately one hour to one hour and fifteen minutes. The heel scan and pedometer programming/instruction took fifteen to twenty minutes.

On the sixth or seventh day of NL-1000 pedometer wear, participants received a follow-up call. The participants were asked to break the seal on the activity monitor and read the amount of activity performed on each day of wear to the researcher, who recorded the information. The participant was reminded to return the monitor and log in the postage paid envelope. During this follow-up phone call, the MAQ past week interview was administered. Estimated time for collection of pedometer information and interview during this contact was thirty minutes. At this time participants were verbally given their calcaneal ultrasound results as a token of appreciation for their participation. Following receipt of the monitor, personal heel scan and objective physical activity results and feedback were mailed to each participant (Appendix I).

When the returned monitor was received by the researcher, data were compared to the activity monitor log and entered into Excel on a secure, password protected PC. In order for data to be used in this study, the monitor must have reflected a minimum of three complete days of usual wear, including one weekend day, in order to achieve a reliable (ICC=0.80) estimate of physical activity (Corder et al., 2007; Tudor-Locke et al., 2005). A participant had to wear the monitor for at least eight hours per day for the data to be considered a "complete day," which was determined by completion of the on and off log. If a participant did not wear the monitor for at least three complete days or if the monitor malfunctioned, the participant was asked to wear the monitor a second time, until at least three days of data were acquired.

Data Analysis

All questionnaires were examined for completeness and data were entered into and analyzed using the Statistical Package for the Social Sciences (SPSS, version 14.0). Six independent social cognitive study variables and five physical activity dependent study variables were analyzed. Independent variables included task self-efficacy (SE_T), barrier self-efficacy (SE_B), social support from friends (SS_{FR}), social support from family (SS_{FA}), perceived access to facilities (AC_F), and perceived access to home equipment (AC_H). Two objective physical activity variables included average steps per day (steps/day) and average minutes per day spent in MVPA (MVPA-min/day). Three subjective physical activity variables included past year average weekly MVPA (YR-MV-MET-hrs/wk), past week leisure MVPA (LMV-MET-hrs/wk), and past week occupational/transport MVPA (OMV-MET-hrs/wk).

Potential control variables for this study included age (yr); BMI (kg/m^2); household annual income (<$24,999; $25,000-34,999; $35,000-49,999; $50,000-74,999; $75,000-99,999; $100,000+); and highest level of education (high school no diploma; high school diploma or GED; some post high-school; associates; bachelors; post-graduate), as these have been shown to be determinants of physical activity (Brownson et al., 2000; Trost et al., 2002). Each of these variables was initially coded with values ranging from 1 through 6, with *1* representing the lowest income and education categories and *6* representing the highest income and education categories. Descriptive variables included calcium (mg/day), vitamin D (IU/day), heel stiffness (QUI), and estimated BMD (g/cm^2). Other categorical variables used for descriptive purposes included menopausal status, race, marital status, number of biological children, smoking status, and alcohol consumption. The following describes the preliminary and specific analyses that were conducted in relation to each specified research aim.

Preliminary Analysis

Prior to conducting each analysis according to the specified research aims, all data were evaluated for missing values. Frequencies were determined for all variables, and histograms and probability plots were examined in order to determine if assumptions of normality were met. Guided by these results, a log transformation of BMI was used due to the distribution that was skewed to the right. The distributions of other variables were within acceptable ranges (the absolute value of skewness was within two times the standard error of skewness), with the exception of social support from friends. Rather than conducting a log transformation of social support from friends, the potential impact of this variable was further evaluated during subsequent analyses using a quasi non-parametric parallel analysis approach.

Descriptive statistics (i.e., mean, median, SD, interquartile range) were estimated for independent, dependent, control, and continuous and categorical descriptive variables. Analysis of variance (ANOVA) models were used to investigate income level and highest level of education-specific mean differences for each dependent and independent continuous variable. The significant income- and education-specific mean differences for each independent variable were used to evaluate the relationships between the categorical and continuous variables. The significant income and education specific-mean differences for each dependent variable were examined, and Tukey post hoc analyses were used to identify income or education categories that could be combined. Guided by these results, income and education were collapsed into three categories. The revised household annual income categories included ≤ $49,999, $50,000-99,999, and $100,000+. The revised highest level of education categories included ≤ high school diploma or GED (including some post-high school), associates or bachelor's degree, and post-graduate degree. Two indicator variables were then created to represent each of the three levels of income and education in linear regression and moderation-mediation analyses.

Although subsequent analyses involved grouping peri- and postmenopausal women, frequencies and descriptive statistics for independent and dependent variables were also determined by menopausal status, and between group differences for these independent and dependent variables were examined.

Bivariate Analysis

Bivariate analysis was conducted for each pair of study variables and scatterplots were examined to determine if assumptions of linearity were met. These data were also visually inspected for potential outliers, which may falsely create or suppress significant associations. Potential outliers were further evaluated during stepwise linear regression analysis. Pearson and Spearman rank correlation coefficients were estimated to examine relationships among all independent, dependent, and control variables. Consistency between these parametric and non-parametric correlation coefficients was confirmed. The correlation coefficients and collinearity statistics were used to detect multi-collinearity between pairs of variables, a problem that is known to cause misleading interpretations of model fitting results. These results and a calculated tolerance of < 0.20 were used as indicators of multi-collinearity, which was also examined during stepwise linear regression analysis.

Stepwise Linear Regression Analysis

Stepwise linear regression analysis (forward-backward combination) was used to assess the relationship of each independent individual, social, and environmental variable with each physical activity dependent variable. Age, BMI, income, and education were considered as potential control variables, and entered first as one block into the models (Block 1). The independent study variables were entered into the models using a stepwise approach as a second block (Block 2). The variable with the highest squared correlation coefficient (R^2) was considered for entry into the regression models first. The entry criterion was $p < 0.05$ and the exit criterion was $p > 0.10$. Of the remaining variables, the one with the highest R^2 was considered for entry, and entry/exit criteria were applied. This process continued until the final models were established.

Upon completion of the forward-backward data selection process, R^2 values were examined in order to determine the proportion of variance in physical activity explained by the factors that entered the model, after adjusting for the other variables in the model. R^2 change values were examined to determine the proportion of additional variance explained as each variable entered the model. Beta weights were also inspected to identify the estimated change in each physical activity outcome predicted by a unit change in each independent variable. This stepwise regression analysis was run for objectively measured steps per day and MVPA minutes per day, as well as subjectively assessed past year MVPA, past week leisure MVPA, and past week occupational/transport MVPA.

Potential outliers were evaluated by examining standardized residuals. An outlier was defined in this study as a standardized residual that was three or more standard deviations from the mean (Fox, 1991). Additionally, Cook's distance was used to estimate how elimination of this data point could affect the analysis. Data points with Cook's distance > 1.0 were further examined and considered for exclusion (Kleinbaum, Kupper, Muller, & Nizam 1998). The leverage statistic was examined to determine if one data point had a greater effect on the model than the other data points. Cases with a leverage statistic > 0.5 were examined more closely. For suspected outliers, regression models were fit with and without the data point, and the differences in parameter estimates were compared. Tolerance statistics (< 0.20) were examined to detect multi-collinearity, which was not found to be a problem in this study.

Stepwise linear regression analysis was used for two primary purposes. First, it allowed variables that explained a greater proportion of the variance in physical activity to enter the model first, thereby demonstrating which variable best explained physical activity in comparison to the other variables. This provided guidance as to which social cognitive variables were most important for physical activity behavior relative to other variables. Additionally, stepwise linear regression analysis provided a method to determine the total proportion of variance in the physical activity measures explained by the variables that entered the model. This indicated which social cognitive variables, in combination, were important for characterizing physical activity behavior. The models identified through these stepwise linear regression analyses were further evaluated for plausibility prior to acceptance in this study.

Moderation Analysis

An examination of the strength of bivariate associations, along with knowledge of existing relationships found in the literature were used to help guide the moderation-mediation analysis for this study as diagrammed in Figure 2. Moderation (interaction) analysis was first conducted to determine if the effect of an independent variable on physical activity varied at different levels of another independent variable. Forty regression models were examined, which consisted of eight different analyses for each of the five physical activity outcome variables. Each of the eight moderation analyses included three main effects (SE, SS, AC); two, two-way interaction effects (SE×SS and SE×AC); and one, three-way interaction effect (SE×SS×AC) (Table 5). Age, BMI, income, and education were considered as potential control variables and entered first as one block into the models (Block 1). This was followed by the main effects (Block 2), two-way interaction effects (Block 3), and three-way interaction effect (Block 4).

The two self efficacy effects (SE_T and SE_B) were not considered together in the same models in order to avoid multi-collinearity problems associated with variables that represent the same general construct. The two social support effects (SS_{FR} and SS_{FA}) and the two access effects (AC_F and AC_H) were also handled in this manner. Additionally, no interaction effects between SS and AC were examined, which was determined *a priori* (see Figure 2) based on knowledge of relationships reported in the literature.

Table 5. Moderation Analysis Performed for Each Physical Activity Variable.

	Main Effects	Two-Way Interaction Effects	Three-Way Interaction Effects
Analysis 1	SE_T		
	SS_{FR}	$SE_T \times SS_{FR}$	
	AC_H	$SE_T \times AC_H$	$SE_T \times SS_{FR} \times AC_H$
Analysis 2	SE_B		
	SS_{FR}	$SE_B \times SS_{FR}$	
	AC_H	$SE_B \times AC_H$	$SE_B \times SS_{FR} \times AC_H$
Analysis 3	SE_T		
	SS_{FA}	$SE_T \times SS_{FA}$	
	AC_H	$SE_T \times AC_H$	$SE_T \times SS_{FA} \times AC_H$
Analysis 4	SE_B		
	SS_{FA}	$SE_B \times SS_{FA}$	
	AC_H	$SE_B \times AC_H$	$SE_B \times SS_{FA} \times AC_H$
Analysis 5	SE_T		
	SS_{FR}	$SE_T \times SS_{FR}$	
	AC_F	$SE_T \times AC_F$	$SE_T \times SS_{FR} \times AC_F$
Analysis 6	SE_B		
	SS_{FR}	$SE_B \times SS_{FR}$	
	AC_F	$SE_B \times AC_F$	$SE_B \times SS_{FR} \times AC_F$
Analysis 7	SE_T		
	SS_{FA}	$SE_T \times SS_{FA}$	
	AC_F	$SE_T \times AC_F$	$SE_T \times SS_{FA} \times AC_F$
Analysis 8	SE_B		
	SS_{FA}	$SE_B \times SS_{FA}$	
	AC_F	$SE_B \times AC_F$	$SE_B \times SS_{FA} \times AC_F$

SE_B = Barrier Self-Efficacy; SE_T = Task Self-Efficacy; SS_{FA}= Social Support Family; SS_{FR} = Social Support Friends; AC_F = Access to Facilities; AC_H = Access to Home Equipment.

The null hypothesis that the parameters representing the three-way interaction effect in each analysis was equal to zero was first tested. The impact on a model of including the three-way interaction effect was examined, comparing it to a reduced model that did not contain the three-way interaction effect. For instance:

$$\text{Full: } Y = \beta_0 + \beta_1 SS + \beta_2 AC + \beta_3 SE + \beta_4 SE \times SS + \beta_5 SE \times AC + \beta_6 SE \times SS \times AC + E$$

$$\text{Reduced: } Y = \beta_0 + \beta_1 SS + \beta_2 AC + \beta_3 SE + \beta_4 SE \times SS + \beta_5 SE \times AC + \ldots\ldots\ldots\ldots + E$$

The three-way interaction effect was evaluated for significance using an F-test, and if significant, a data plot was produced and examined for meaningfulness and interpretability. The number of observations for each model predictor was considered in the analysis and interpretation. If no significant three-way interaction effect was detected, according to the principle of parsimony (Kleinbaum et al., 1998), it was eliminated from the model and two-way interaction effects were examined for significance. If the two-way interaction effects made a significant contribution to the explanation of any of the physical activity outcome measures, data plots were generated and examined for meaningfulness and interpretability. If significant interaction effects were detected for a specific physical activity outcome in the moderation analysis, no mediation analysis involving those variables was conducted.

Moderation analysis was conducted for two primary purposes. First, it allowed identification of factors that modified the effect of other factors to influence physical activity behavior. This indicated which social cognitive variables influenced the association between other social cognitive variables and physical activity. Second, this analysis informed the conditions under which these interaction effects took place. In other words, it indicated how the relationship between one social cognitive variable and physical activity varied at different levels of another (moderating) social cognitive variable.

Mediation Analysis

Where no significant interaction effects were detected in moderation analysis, mediation (confounding) analysis was then conducted. Independent study variables and control variables had to be associated with both the physical activity outcome variable and the mediator to be included (Baron & Kenny, 1986). While more than 240 mediation models could have been examined, based on the significant results detected during the moderation analysis, 96 mediation models were examined. For each model, the hypothesis was that the parameter representing the mediator (β_3) was equal to zero. In this analysis the crude model containing only the independent study variables of interest ($\beta_1 X_1 + \beta_2 X_2$) was compared to the adjusted model which also included a potential mediating variable ($\beta_3 X_3$; Baron & Kenny, 1986). For instance:

Crude: $Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots + \text{Control Variables} + E$

Adjusted: $Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \text{Control Variables} + E$

The change in β for each study variable of interest (here β_1 and β_2) was statistically compared between the crude and adjusted models using an F-test. If the addition of the mediator β_3 caused a significant change in β_1 or β_2 for any of the physical activity variables, this indicated the effects of study variables ($X_1 + X_2$) on physical activity were confounded by the potential mediating variable (X_3; Kleinbaum et al., 1998).

The primary purpose of mediation analysis was to identify how one social cognitive variable was associated with physical activity through another social cognitive variable. This informed the indirect associations between social cognitive variables and measures of physical activity.

Research Aims and Analyses

The statistical analyses specifically outlined above were used to achieve the three primary aims of this study. In summary, the aims and analyses were as follows:

1. *Describe select factors associated with the MVPA of peri- and postmenopausal women. More specifically, this included an examination of:*

Individual: Task and barrier self-efficacy;

Social: Social support from family and friends; and

Environmental: Access to facilities and home equipment.

Bivariate correlation coefficients were estimated to describe the strength of the association between each independent variable and each of the physical activity outcome measures.

2. *Test the relative contribution of the individual, social, and environmental factors in explaining the MVPA of peri- and postmenopausal women.*

Stepwise linear regression analysis was conducted to identify the combination of independent variables that explained the largest proportion of the variance in each of the physical activity outcome measures. R^2 change values indicated the additional proportion of variance explained as each variable entered the model, after adjusting for the other variables in the model. The models obtained using the stepwise analyses were examined for plausibility prior to acceptance in this study.

3. *Describe the strength of direct and indirect associations of individual, social, and environmental factors with MVPA of peri- and postmenopausal women.*

Moderation analysis (interaction, effect modification) was conducted to determine if the relationships of independent variables with each dependent physical activity variable varied at different levels of another independent variable. When interaction effects were not present, the confounding effects (mediation) of independent variables on physical activity were examined.

CHAPTER IV

RESULTS

The primary purpose of this study was to utilize Social Cognitive Theory (SCT) to understand and describe determinants of moderate to vigorous physical activity (MVPA) for osteoporosis (OP) prevention among peri- and postmenopausal women. The results of this study are presented in this chapter, beginning with a description of participants and study variables. In addition, the relationships among independent social cognitive variables and various aspects of physical activity are presented according to each specified research aim.

Participant Characteristics

Ninety-eight women expressed interest and were contacted about participation in this study. Of the ninety-eight women initially interested, six did not meet the inclusion criteria and two canceled their appointments following screening and chose to not reschedule. One cancellation was due to participant schedule constraints, and the other cancellation was due to a chronic orthopedic condition that prevented performance of normal daily physical activity. Ninety peri- and postmenopausal women (21 perimenopausal and 66 postmenopausal) consented to participate in the study, which involved completing a series of questionnaires, interviews, and wearing a physical activity monitor. All participants completed all questionnaires and interviews. Only one participant did not wear the physical activity monitor, and two participants did not wear the monitor for at least eight hours for a minimum of three days. Thus, 87 participants successfully completed the study, resulting in an adherence rate of 96.7%. These 87 participants were included in all final analyses.

The women who participated in this study ranged in age from 43 to 65 years (Mean = 55.0, SD = 5.46). All women were from Eastern Iowa or Western Illinois, and 36% of them were from rural communities. Demographic and health information for all participants may be found in Table 6. Descriptive statistics for independent variables and dependent variables for all participants and by menopausal status may be found in Tables 7, 8, and 9.

Although all subsequent analyses involved placing peri- and postmenopausal women into one group, independent sample t-tests were conducted to examine the differences between these groups for all continuous study variables. Results indicated the only significant differences existed between peri- and postmenopausal women for age $t(85) = -5.38$, $p < 0.0001$ and access to home equipment $t(85) = 2.87$, $p = 0.007$. A two-way contingency table analysis was conducted to examine distribution of peri- and postmenopausal women in the three categories of income and education. Although not significant at the $p < 0.05$ level, the Pearson chi-square statistic suggested differences for income $\chi^2(2\ df, N = 87) = 4.98$, $p = 0.08$ and education $\chi^2(2\ df, N=87) = 5.16$, $p = 0.08$. The difference in age was expected, where postmenopausal women reported higher mean values for age than did the perimenopausal women. The significant difference between menopausal status groups for access to home equipment may have been affected by the slight differences in income distributions between the two groups, as there was a significant mean difference in access to home equipment across income categories (Table 10). These differences were not considered to be an issue in this study; therefore, all subsequent analyses proceeded as planned, by placing participants into one group.

Analysis to Address Research Aims

Research Aim 1

The first research aim was to describe select social cognitive factors associated with the MVPA of peri- and postmenopausal women. One-factor ANOVA models were used to investigate income and education category mean differences in all continuous study variables. Results of this analysis can be found in Tables 10 and 11, which includes the coefficient of determination (R^2) and income and education category mean differences. Tukey post hoc analyses were used to make pairwise comparisons between observed means across each level of income and education.

Spearman rank correlation coefficients were estimated for each (continuous) potential control variable and independent variable with each of the physical activity outcome measures (Table 12). An examination of correlations between independent and dependent study variables indicated task self-efficacy had the strongest relationships with MVPA-minutes per day ($r = 0.39$, $p < 0.01$) and past week leisure MVPA ($r = 0.38$, $p < 0.01$). Barrier self-efficacy had the strongest association with MVPA-minutes per day ($r = 0.45$, $p < 0.01$), closely followed by modest associations with steps per day ($r = 0.40$, $p < 0.01$) and past week leisure MVPA ($r = 0.43$, $p < 0.01$). Family social support was most strongly associated with past year MVPA ($r = 0.40$, $p < 0.01$), and friend social support was most strongly associated with steps per day ($r = 0.27$, $p < 0.05$). Access to home equipment was most strongly associated with MVPA-minutes per day (0.33, $p < 0.01$), and access to facilities was inversely associated with past week occupational activity ($r = -0.25$, $p < 0.05$). The overall results of the bivariate correlation analysis indicate significant relationships exist between social cognitive variables and various measures of physical activity among peri- and postmenopausal women.

Research Aim 2

The second research aim was conducted to identify the social cognitive variables that explained the largest relative proportion of the variance in physical activity. Separate stepwise linear regression analyses were conducted considering all of the social cognitive independent variables as possible predictors of each of the physical activity dependent variables. Age, BMI, income, and highest level of education were considered for entry into each model prior to entering the social cognitive variables. Entry of these control variables was guided by significant mean differences and significant correlations ($p < 0.05$) found in this study, as well as support for their association with physical activity in the existing literature. If the control variables were not associated with the study variables included in the model, the models were fit with and without the block of control variables. The block of control variables was then forced into the final models, as long as standard errors of parameter estimates did not increase considerably between the two regression models (with and without control variables). This maintained consistency across each regression model for each physical activity outcome.

Results of the regression analysis for each physical activity outcome are listed in Tables 13, 14, and 15 including estimates of the beta coefficients, standard errors, R^2, R^2 change, and p values associated with the control variables and each independent variable. Figure 3 displays the significant R^2 change values for each independent variable that entered the models for each physical activity outcome variable. Outliers were identified in three of the five regression models. These instances are indicated in each table.

Regression diagnostics were used, and the collinearity statistics examined during this phase of the stepwise regression analysis indicated that collinearity was not an issue in this study.

Steps per Day

When the control and independent variables were regressed onto steps per day, results indicated that age, income, education, and BMI (entered as one block), as well as barrier self-efficacy and social support from friends were significant predictors, explaining 15%, 12%, and 5% of the variance in steps per day, respectively. Collectively these variables explained 32% of the total variance in steps/day (Table 13).

MVPA Minutes per Day

For MVPA-minutes per day, the control block was forced into the model, explaining 16% of the variance. The only social cognitive variable to enter the model was barrier self-efficacy, which explained an additional 10% of the variance. The final model explained 26% of the variance in MVPA-minutes per day (Table 13).

Past Year MVPA

For past year MVPA, the control block was forced into the model, explaining 14% of the variance. When the social cognitive independent variables were then regressed onto past year MVPA, barrier self-efficacy, social support from family, and access to facilities entered the model. These variables explained an additional 10%, 9%, 6% of the variance, respectively. When considered together, these variables explained 39% of the variance in past year MVPA (Table 14).

Past Week Leisure MVPA

For past week leisure MVPA, the control block explained 3% of the variance. The only independent variables that entered into the regression model included barrier self-efficacy and social support from friends, explaining an additional 18% and 5% of the variance, respectively. When these variables were considered collectively, they explained 26% of the variance in past week leisure MVPA (Table 15).

Past Week Occupational/Transport MVPA

Age, income, education, BMI, and each of the social cognitive independent variables were regressed onto past week occupational/transport MVPA. Results indicated the control block explained 17% of the variance. The only social cognitive variable that entered the model was access to facilities, which explained an additional 10% of the variance. Collectively, these variables explained 27% of the variance in occupational/ transport activity (Table 15).

In order to confirm the robustness of these linear stepwise regression analyses, a quasi non-parametric rank transformation approach was used to conduct parallel analyses. Each of the control, independent, and dependent variables was rank transformed, and stepwise linear regression models were developed based on the ranked data in the same manner as described for the non-transformed data. Results of the rank transformation analysis showed the variables that entered the models were consistent with the original regression analyses for four of the five models, including steps per day, MVPA minutes per day, past year MVPA, and past week occupational/transport MVPA. For past week leisure MVPA, both barrier self-efficacy and social support from friends entered the original stepwise linear regression model, explaining 18% and 5% of the variance in past week leisure MVPA; however only barrier self-efficacy entered the rank transformed linear regression model, explaining 17% of the variance in past week leisure MVPA. While the data used in this study were determined to be within acceptable normality ranges, these data should be interpreted with caution as the degree of skewness of social support from friends may have affected the variables that entered the model for past week leisure MVPA. On the other hand, the rank transformation approach is considerably less powerful, and the social support from friends explained only 5% of the variance in the parametric analysis.

Research Aim 3

The third aim of this study was to determine if significant interaction effects (moderation) or confounding effects (mediation) existed between independent variables or groups of independent variables, thereby influencing the relationship between the independent variables and each dependent physical activity variable (Figure 2, Chapter 2).

Moderation Analyses

Moderation analysis allows the effect of an independent variable on physical activity to vary at different levels of another independent variable by calculating two-way and three-way interaction effects in the model. As described in the data analysis section of this study, forty regression models were investigated, which consisted of eight different analyses for each of the five physical activity outcome variables. Each of the eight moderation analyses included three main effects (SE, SS, AC); two, two-way interaction effects (SE×SS, SE×AC); and one, three-way interaction effect (SE×SS×AC). Age, BMI, income, and highest level of education were considered for entry into the regression models first (Block 1). Similar to procedures used during stepwise linear regression analysis, the models were fit with and without the control variables. In order to maintain consistency between models fit for each physical activity outcome, the control variables were forced into the models if their entry did not have a substantial effect on standard errors of parameter estimates. The entry of control variables was followed by the entry of the main effects (Block 2), two-way interaction effects (Block 3), and then the three-way interaction effect (Block 4). The three-way interaction effect was examined for significance, and if it was not significant, the two-way interaction effects were examined for significance. Table 5 (Chapter 3) outlines the combinations of variables examined in moderation analysis.

Tables 16, 17, and 18 list the beta coefficients, standard errors, standardized beta coefficients, R^2, R^2 change, and p values for each of the full models where interaction effects were found. Overall, analyses revealed one significant three-way interaction effect for steps per day. This included an interaction effect between barrier self-efficacy, social support from friends, and access to facilities. For both past year MVPA and past week leisure MVPA, significant two-way interaction effects were found between barrier self-efficacy and social support from friends. For moderation analyses involving MVPA minutes per day and past week occupational/transport MVPA, no significant interaction effects were found.

Parallel rank transformation analyses were conducted to confirm the interaction effects. The control and independent variables were rank transformed and interaction effects of the rank transformed variables were calculated. All variables were entered into the models in the same manner described for the original analysis. Results of the rank transformation analysis confirmed the results of the moderation analysis for past year MVPA and past week leisure MVPA. However, results of the transformation analysis for steps per day revealed the three-way interaction effect was not significant ($F (1, 72) = 2.27$, $p = 0.137$). This indicates the parametric moderation results for steps per day should be interpreted with caution. On the other hand, due to the loss of power that occurs with non-parametric approaches, the relatively low p-value found during the transformation analysis, and the plausibility of the interaction effect, it was determined the parametric moderation results should be reported in this study.

Steps per day. Moderation analysis identified a significant three-way interaction effect among barrier self-efficacy, social support from friends, and access to facilities on steps per day. Based on this significant interaction effect, the beta coefficients for each predictor were pooled and the following fitted model was generated:

$$\hat{Y} = [[(3664.30) + (-59.74 \times SS_{FR}) + (-159.85 \times AC_{F}) + (3.45 \times SS_{FR} \times AC_{F})] \times SE_{B} + [(127.52 \times SS_{FR}) + (180.73 \times AC_{F})] - 968.23]$$

The modifying effects of social support and access to facilities on barrier self-efficacy were evaluated at selected values based on the mean and standard deviation of social support (23.53, SD = 10.22) and access to facilities (11.16, SD = 4.81). These values represented three levels of social support from friends and three levels of access to facilities. The three levels of social support from friends included the mean (23.53), the mean plus one SD (33.75), and the mean minus one SD (13.31). The three selected values representing the three levels of access to facilities included the mean (11.16), the mean plus one SD (15.97), and the mean minus one SD (6.35). The fitted model was evaluated at each combination of these values, resulting in nine regression models that allowed the prediction of steps per day based on barrier self-efficacy (Table 19).

Data plots based on these nine regression models were generated for meaningfulness and interpretability (Figures 4, 5, and 6). Overall, plots revealed that for each combination of access and social support, an increase in barrier self efficacy was associated with an increased number of steps per day. Among women with low levels of access, for those with low levels of social support, an increase in barrier self-efficacy was associated with a greater increase in the number of steps per day (β_1 = 2145.70) than for women with moderate (β_1= 1759.05) or high (β_1 = 1372.40) levels of social support (Figure 4). Likewise, among women with moderate levels of access, for those with low levels of social support, an increase in barrier self-efficacy was associated with a greater increase in the number of steps per day (β_1 = 1597.69) than for women with moderate (β_1 = 1380.64) or high (β_1 = 1163.58) levels of social support (Figure 5). The same was also found among women with high levels of access, where for those with low social support, an increase in barrier self-efficacy was associated with a larger increase in the number of steps per day (β_1 = 1049.69) than for women with moderate (β_1 = 1003.89) or high (β_1 = 954.78) social support (Figure 6).

Past year MVPA. Moderation analysis conducted with past year MVPA as the dependent variable revealed two significant two-way interaction effects. One analysis involving barrier self-efficacy, social support from friends, and access to home equipment showed a significant two-way interaction effect between barrier self-efficacy and social support from friends. A second analysis which involved barrier self-efficacy, social support from friends, and access to facilities, also revealed a significant two-way interaction effect between barrier self-efficacy and social support from friends. These analyses indicated barrier self-efficacy and social support from friends interacted to influence past year MVPA.

Because the full models involving these variables showed no significant three-way interaction effects, one reduced model was generated which included the significant two-way interaction effects (Table 20). Based on the reduced model, the beta coefficients for each predictor were pooled and the following fitted model was generated:

$$\hat{Y} = [[(-16.17) + (1.61 \times SS_{FR})] \times SE_B + (-5.17 \times SS_{FR}) + 76.96]$$

The modifying effect of social support on barrier self-efficacy was evaluated at three selected values representing the three levels of social support from friends, including the mean (23.53), the mean plus one SD (33.75), and the mean minus one SD (13.31). The fitted model was evaluated at each of these values, resulting in three regression models (Table 21). Data plots were generated for meaningfulness and interpretability. Plots revealed that at high levels of social support, an increase in barrier self-efficacy was associated with a larger increase in past year MVPA ($\beta_1 = 38.17$) than for low ($\beta_1 = 5.26$) and moderate ($\beta_1 = 21.71$) levels of social support (Figure 7). These findings support the moderating effect of social support from friends on barrier self-efficacy.

Past week leisure MVPA. Moderation analysis conducted with past week leisure MVPA as the dependent variable revealed two significant, two-way interaction effects. One analysis involving barrier self-efficacy, social support from friends, and access to home equipment, showed a significant two-way interaction effect between barrier self-efficacy and social support from friends. A second analysis involving barrier self-efficacy, social support from friends, and access to facilities, also revealed a significant two-way interaction effect between barrier self-efficacy and social support from friends. Similar to past year MVPA, these analyses indicated barrier self-efficacy and social support from friends interacted to influence past week leisure MVPA.

Based on the significant interaction effect between barrier self-efficacy and social support from friends found in the full models, one reduced model was generated (Table 22). The beta coefficients for each predictor were pooled and the following fitted model was generated:

$$\hat{Y} = [[(-11.73) + (1.07) \times SS_{FR})] \times SE_B + (-3.43 \times SS_{FR}) + 33.31]$$

The modifying effect of social support on barrier self-efficacy was evaluated at three selected values representing three levels of social support from friends, including the mean (23.53), the mean plus one SD (33.75), and the mean minus one SD (13.31). The fitted model was evaluated at these values, resulting in three regression models (Table 23). Data plots were generated for meaningfulness and interpretability. Plots revealed that at high levels of social support, an increase in barrier self-efficacy was associated with a larger increase in past week leisure MVPA ($\beta_1 = 24.39$) than for low ($\beta_1 = 2.51$) and moderate ($\beta_1 = 13.45$) levels of social support (Figure 8). These findings support the moderating effect of social support from friends on barrier self-efficacy.

Mediation Analyses

For those physical activity dependent variables where no significant interaction effects were identified, the confounding effects (mediation) of independent variables on physical activity were examined. In order to be considered for the mediation analysis, the group of variables entered in the mediation analysis could not (collectively) be part of the significant interaction effects detected in moderation analyses. Additionally, potential mediators had to be associated with control variables, independent variables, and the outcome variable to be included in the mediation models. Control variables that met these criteria were entered as one block into the models. This was followed by the entry of independent study variables as a second block in the models. The potential mediating variable was then entered in the third block of the models. All independent variables eligible for entry into the model were strategically rotated through the models as a potential mediator between other independent study variables in the model and the specific physical activity outcome variable.

For each analysis, the full model which included all variables (including the mediator) was compared to the crude model (without the mediator). Change in beta for each independent variable was compared between the crude and adjusted model using an F-test. Additionally, if a significant change in beta was detected, the meaningfulness of this effect was determined prior to acceptance of the model. If the addition of the mediator caused a significant *and* meaningful change in beta, the mediation results were accepted.

Ninety-six models were examined for mediation, however, only one significant, meaningful mediation effect was found in the analysis of past year MVPA. In this analysis, BMI, education, barrier self-efficacy, and access to equipment represented the crude model. When social support from family entered the model, the beta weight for barrier self-efficacy significantly decreased ($F(1,83) = 5.71$, $p = 0.019$). The change in beta between the crude and full models was evaluated for meaningfulness, where the beta weight for barrier self-efficacy decreased by 4.49. This indicates the effect of barrier self-efficacy on past year MVPA decreased by 4.49 moderate to vigorous MET-hours per week ($\geq$ 3.0 METS) when social support from family entered the model. This is equivalent to performing more than 30 minutes of moderate activity (3.0 METS), 12 times per month, 12 months per year, and was determined to be meaningful in this study. This indicates social support from family confounds the effect of barrier self-efficacy on past year MVPA in peri- and postmenopausal women.

Table 6. Participant Demographic and Health Information.

Variable	**Mean**	**SD**
Age (yrs)	55.0	5.46
BMI (kg/m^2)	26.39	5.32
Heel BMD (g/cm^2)	0.591	0.143
Heel Stiffness (QUI)	105.17	22.71
Calcium Intake (mg/day)	1237.45	649.98
Vitamin D (IU/day)	344.42	207.39

Variable	**Category**	**N (%)**
Race (%)	Hispanic or Latino	2 (2.3)
	Caucasian	82 (94.3)
	Multi-racial	1 (1.1)
	Other	2 (2.3)
Household Annual Income (%)	≤ 49,999	11 (12.4)
	50,000-99,999	37 (41.6)
	100,000+	34 (39.1)
Highest Education (%)	≤ High School Diploma/GED	32 (36.8)
	A.A. or Bachelor's Degree	28 (32.2)
	Post Graduate Degree	33 (37.9)
Menopausal Status (%)	Perimenopausal	21 (24.1)
	Postmenopausal	66 (75.9)
Marital Status (%)	Never Married	4 (4.6)
	Widowed	2 (2.3)
	Divorced	4 (4.6)
	Married	77 (88.5)
Alcohol Servings Per Wk (%)	0	34 (39.1)
	1-2	23 (26.4)
	3-4	12 (13.8)
	5+	18 (20.7)
Smoking Status (%)	Never Smoked	59 (67.8)
	Former Smoker	26 (29.9)
	Smoker	2 (2.2)

QUI = Quantitative Ultrasound Index; IU = International Units; ≤ High School Diploma or GED includes some education post high school; A.A. = Associates Degree

Table 7. Participant Descriptive Statistics for Independent Variables.

	Mean	Median	SD	25th %'ile	75th %'ile
Task Self-Efficacy	74.7	75.8	16.6	67.3	87.6
Barrier Self-Efficacy	3.5	3.6	0.8	2.9	4.2
Social Support Family	29.5	27.0	12.3	20.0	37.0
Social Support Friends	23.5	22.0	10.2	15.0	29.0
Access to Home Equipment	5.7	5.0	2.3	4.0	7.0
Access to Facilities	11.1	12.0	4.8	6.0	15.0

SD = Standard Deviation

Table 8. Participant Descriptive Statistics for Dependent Physical Activity Variables.

	Mean	Median	SD	25th %'ile	75th %'ile
Steps/day	8824.9	8054.0	3305.2	6302.0	11067.0
MVPA-min/day	25.8	21.0	16.4	13.7	34.8
YR-MV-MET-hr/wk	64.2	52.3	49.6	25.6	94.2
LMV-MET-hr/wk	25.6	20.7	22.1	7.1	36.0
OMV-MET-hr/wk	28.9	12.0	39.4	0.0	45.0

MVPA = Moderate to Vigorous Physical Activity; Steps/day = Steps per Day; MVPA-min/day = MVPA Minutes per Day; LMV-MET-hr/wk = Past Week Leisure MVPA; OMV-MET-hr/wk = Occupational/Transport MVPA; YR-MV-MET-hr/wk = Past Year MVPA.

MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

SD = Standard Deviation

Table 9. Descriptive Statistics for Independent and Dependent Variables by Menopausal Status.

	Perimenopausal (n = 21)		Postmenopausal (n = 66)	
	Mean	SD	Mean	SD
Independent Variables				
Task Self-Efficacy	76.5	17.8	74.1	16.2
Barrier Self-Efficacy	3.7	0.8	3.5	0.8
Social Support Family	33.1	10.5	28.3	12.6
Social Support Friends	27.0	11.0	22.4	9.4
Access to Home Equipment	6.9**	2.1	5.3	2.2
Access to Facilities	12.6	3.7	10.7	5.0
Dependent Variables				
Steps/day	8685.2	3577.4	8869.4	3241.5
MVPA-min/day	25.2	18.2	25.9	15.9
YR-MV-MET-hr/wk	70.3	52.4	62.2	48.9
LMV-MET-hr/wk	28.6	23.9	24.6	21.6
OMV-MET-hr/wk	21.7	24.9	31.2	42.9

MVPA = Moderate to Vigorous Physical Activity; Steps/day = Steps per Day; MVPA-min/day = MVPA Minutes per Day; LMV-MET-hr/wk = Past Week Leisure MVPA; OMV-MET-hr/wk = Occupational/Transport MVPA; YR-MV-MET-hr/wk = Past Year MVPA.

Note: MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

SD = Standard Deviation

* t-test $p < 0.05$, ** t-test $p < 0.01$

Table 10. Coefficient of Determination (R^2) from Analysis of Variance of All Continuous Study Variables Using Three Income and Education Categories.

	Income R^2	Education R^2
Age	0.10*	0.01
BMI	0.05	0.00
Task Self-Efficacy	0.05	0.01
Barrier Self-Efficacy	0.04	0.01
Social Support Family	0.08*	0.01
Social Support Friends	0.03	0.04
Access to Home Equipment	0.25**	0.08*
Access to Facilities	0.02	0.10*
Steps/day	0.11*	0.00
MVPA-min/day	0.14**	0.03
YR-MET-hr/wk	0.05	0.06
LMV-MET-hr/wk	0.03	0.01
OMV-MET-hr/wk	0.01	0.08*

MVPA = Moderate to Vigorous Physical Activity; Steps/day = Steps per Day; MVPA-min/day = MVPA Minutes per Day; LMV-MET-hr/wk = Past Week Leisure MVPA; OMV-MET-hr/wk = Occupational/Transport MVPA; YR-MV-MET-hr/wk = Past Year MVPA.

Note: MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

* ANOVA $p < 0.05$, ** ANOVA $p < 0.01$

Table 11. Income and Education Category Pairwise Mean Differences from Analysis of Variance of all Continuous Study Variables.

	Income$_{1, 2, 3}$ Pairwise Mean Differences			Education$_{1, 2, 3}$ Pairwise Mean Differences		
	1-2	1-3	2-3	1-2	1-3	2-3
Age	2.26	4.88	-2.26	1.20	1.46	0.25
BMI	0.93	3.10	2.17	0.00	-0.00	-0.01
Task SE	-3.11	-9.50	-6.39	-3.13	-1.76	1.37
Barrier SE	-0.27	-0.48	-0.21	-0.06	0.09	0.15
SS Family	-8.30	-10.76*	-2.45	-3.36	-2.74	0.63
SS Friends	-2.48	-5.20	-2.71	-3.33	-4.45	-1.11
Access Equipment	-1.20	-3.12*	-1.92*	-1.51*	-1.21	0.31
Access Facilities	-0.67	-1.67	-1.01	-2.32	-3.65*	-1.33
Steps/day	-403.51	-2494.82	-2091.32*	-405.40	99.01	504.41
MVPA-min/day	-3.60	-15.14*	-11.54*	-1.98	-6.50	-4.51
YR-MET-hr/wk	-5.27	-25.76	-20.49	-17.85	12.95	30.79*
LMV-MET-hr/wk	3.75	-3.89	-7.64	-2.75	-3.59	-0.83
OMV-MET-hr/wk	13.65	10.61	-3.04	-10.08	19.22	29.31*

MVPA = Moderate to Vigorous Physical Activity; Steps/day = Steps per Day; MVPA-min/day = MVPA Minutes per Day; LMV-MET-hr/wk = Past Week Leisure MVPA; OMV-MET-hr/wk = Occupational/Transport MVPA; YR-MV-MET-hr/wk = Past Year MVPA; Income$_1$ ≤ \$49,999; Income$_2$ = \$50,000-99,999; Income$_3$ ≥ \$100,000; Education$_1$ ≤ High School Diploma or GED; Education$_2$ = Associate's to Bachelor's Degree; Education$_3$ = Post Graduate Degree.

MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

Pairwise comparisons between observed means were made using Tukey post hoc analyses.

* $p < 0.05$, ** $p < 0.01$

Table 12. Spearman Rank Correlation Coefficients among Social Cognitive and Physical Activity Study Variables.

	Age	BMI	Income[†]	Education[†]	Task SE	Barrier SE	SS Family	SS Friend	Access Equipment	Access Facilities
Task SE	-0.03	-0.22*	0.27*	0.02						
Barrier SE	-0.04	-0.38**	0.22*	-0.06	0.69**					
SS Family	-0.11	-0.22*	0.32**	0.10	0.36**	0.35**				
SS Friend	-0.14	-0.00	0.12	0.15	0.17	0.16	0.29**			
Access Equipment	-0.36**	-0.32**	0.50**	0.21	0.24*	0.30**	0.36**	0.22*		
Access Facilities	-0.01	-0.06	0.18	0.32**	0.20	0.32**	0.14	-0.03	0.31**	
Steps/day	-0.15	-0.31**	0.35**	-0.03	0.29**	0.40**	0.27*	0.27*	0.30**	0.06
MVPA-min/day	-0.11	-0.24*	0.42**	0.14	0.39**	0.45**	0.32**	0.23*	0.33**	0.15
YR-MET-hr/wk	-0.10	-0.18	0.21	-0.12	0.25*	0.34**	0.40**	0.23*	0.24**	-0.11
LMV-MET-hr/wk	-0.06	-0.20	0.18	0.05	0.38**	0.43**	0.32**	0.22*	0.26*	0.13
OMV-MET-hr/wk	-0.05	-0.09	-0.07	-0.25*	-0.04	0.06	0.09	0.07	0.04	-0.25*

MVPA = Moderate to Vigorous Physical Activity; Steps/day = Steps per Day; MVPA-min/day = MVPA Minutes per Day; LMV-MET-hr/wk = Past Week Leisure MVPA; OMV-MET-hr/wk = Occupational/Transport MVPA; YR-MV-MET-hr/wk = Past Year MVPA; SE = Self-Efficacy; SS = Social Support.

MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

† = levels coded as 1-6

* $p < 0.05$, ** $p < 0.01$

Table 13. Stepwise Linear Regression Analysis Models Derived Using Each Social Cognitive Independent Variable to Predict Steps per Day and MVPA Minutes per Day.

	$\hat{\beta}$	Standard Error	R^2	R^2 Change	p value
Steps/day^					
Block 1			0.15	0.15	0.060
Age	-17.47	57.80			
BMI	-2784.70	4086.89			
$Income_2$	-100.26	960.67			
$Income_3$	1229.77	1060.93			
$Education_2$	-879.73	777.43			
$Education_3$	-836.27	761.99			
Block 2					
Barrier Self-Efficacy	1321.40	422.48	0.27	0.12	0.001
Social Support Friends	71.67	31.17	0.32	0.05	0.024
MVPA-min/day					
Block 1			0.16	0.16	0.036
Age	0.03	0.32			
BMI	3.63	22.48			
$Income_2$	0.71	5.33			
$Income_3$	10.77	5.83			
$Education_2$	-1.93	4.26			
$Education_3$	3.28	4.21			
Block 2					
Barrier Self-Efficacy	7.00	2.28	0.26	0.10	0.003

MVPA = Moderate to Vigorous Physical Activity; $Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree.

^-Indicates one observation was excluded from the analysis due to it being an outlier.

Table 14. Stepwise Linear Regression Analysis Models Derived Using Each Social Cognitive Independent Variable to Predict Past Year MVPA.

	$\hat{\beta}$	Standard Error	R^2	R^2 Change	p value
Past Yr MVPA^					
Block 1			0.14	0.14	0.080
Age	0.15	0.90			
BMI	102.65	63.10			
$Income_2$	-1.67	15.15			
$Income_3$	17.58	16.60			
$Education_2$	18.66	12.15			
$Education_3$	-8.87	12.50			
Block 2					
Social Support Family	1.11	0.43	0.23	0.09	0.003
Access to Facilities	-3.73	1.07	0.29	0.06	0.017
Barrier Self-Efficacy	23.36	6.93	0.39	0.10	0.001

MVPA = Moderate to Vigorous Physical Activity; $Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree.

Past Year MVPA measured as average moderate to vigorous (≥ 3.0 METS) MET-hr/week. MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

^-Indicates one case was excluded from the analysis due to it being an outlier.

Table 15. Stepwise Linear Regression Analysis Models Derived Using Each Social Cognitive Independent Variable to Predict Past Week Leisure MVPA and Past Week Occupational/Transport MVPA.

	$\hat{\beta}$	Standard Error	R^2	R^2 Change	p value
Past Wk Leisure MVPA					
Block 1			0.03	0.03	0.897
Age	0.04	0.44			
BMI	23.17	30.80			
$Income_2$	-8.40	7.27			
$Income_3$	-3.96	7.98			
$Education_2$	-0.62	5.83			
$Education_3$	1.96	5.76			
Block 2					
Barrier Self-Efficacy	11.88	3.17	0.21	0.18	< 0.0001
Social Support Friends	0.50	0.24	0.26	0.05	0.038
Past Wk Occupation MVPA^					
Block 1			0.17	0.17	0.031
Age	-0.48	0.63			
BMI	-73.241	43.56			
$Income_2$	-0.07	10.72			
$Income_3$	2.043	11.58			
$Education_2$	3.14	8.71			
$Education_3$	-18.64	8.68			
Block 2					
Access to Facilities	-9.81	0.73	0.27	0.10	0.003

MVPA = Moderate to Vigorous Physical Activity; $Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree.

Note: Past week leisure and occupational/transport MVPA measured as moderate to vigorous (> 3.0 METS) MET-hr/week. MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

^-Indicates one observation was excluded from the analysis due to it being an outlier.

Table 16. Moderation Analysis: Full Model Showing the Significant Three-Way Interaction Effect on Steps per Day.

	$\hat{\beta}$	SE	Std Beta	R^2	R^2 Change	p value
Block 1				0.16	0.16	0.035
Age	-3.80	64.62	-0.01			
BMI	-49.23	69.09	-0.08			
$Income_2$	-258.85	1074.74	-0.04			
$Income_3$	1483.84	1208.98	0.22			
$Education_2$	-107.65	884.18	-0.02			
$Education_3$	-546.92	912.44	-0.08			
Block 2				0.28	0.12	0.013
Barrier Self-Efficacy	3664.30	2020.55	0.89			
Social Support Friends	127.52	202.89	0.39			
Access to Facilities	180.73	358.13	0.26			
Block 3				0.28	0.00	0.944
$SE_B \times SS_{FR}$	-59.74	59.88	-0.81			
$SE_B \times AC_F$	-159.85	113.59	-1.03			
Block 4						
$SE_B \times SS_{FR} \times AC_F$	3.45	1.67	0.71	0.32	0.04	0.043

$Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree. SE_B = Barrier Self-Efficacy; SS_{FR} = Social Support Friends; AC_F = Access to Facilities.
.
SE = Standard Error; Std. Beta = Standardized Beta Coefficient.

Table 17. Moderation Analyses: Full Models Showing No Significant Interaction Effects on Past Year MVPA.

	$\hat{\beta}$	SE	Std Beta	R^2	R^2 Change	p value
Block 1				0.14	0.14	0.075
Age	0.33	1.03	0.03			
BMI	0.80	1.08	0.09			
$Income_2$	6.45	16.92	0.06			
$Income_3$	17.78	19.23	.018			
$Education_2$	4.92	13.59	0.05			
$Education_3$	-20.68	14.22	-0.20			
Block 2				0.25	0.11	0.016
Barrier Self-Efficacy	-24.03	30.12	-0.38			
Social Support Friends	-5.67	3.16	-1.14			
Access to Home Equipment	0.58	10.94	0.27			
Block 3				0.29	0.04	0.145
$SE_B \times SS_{FR}$	1.98	1.08	1.77			
$SE_B \times AC_H$	0.73	3.62	0.153			
Block 4						
$SE_B \times SS_{FR} \times AC_H$	-0.03	0.07	-0.30	0.29	0.00	0.605
Block 1				0.14	0.14	0.075
Age	0.36	0.94	0.04			
BMI	62.75	66.41	0.10			
$Income_2$	7.03	15.65	0.07			
$Income_3$	20.60	17.58	0.20			
$Education_2$	14.03	12.86	0.13			
$Education_3$	-7.98	13.29	-0.08			
Block 2				0.34	0.20	< 0.0001
Barrier Self-Efficacy	-12.48	29.50	-0.20			
Social Support Friends	-5.00	2.96	-1.00			
Access to Facilities	-4.75	5.22	-0.46			
Block 3				0.37	0.03	0.188
$SE_B \times SS_{FR}$	1.54	0.87	-1.38			
$SE_B \times AC_F$	0.56	1.65	0.24			
Block 4						
$SE_B \times SS_{FR} \times AC_F$	-0.01	0.02	-0.08	0.37	0.00	0.810

$Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree. SE_B = Barrier Self-Efficacy; SS_{FR} = Social Support Friends; AC_F = Access to Facilities; AC_H = Access to Home Equipment.

Past Year MVPA measured as average moderate to vigorous (≥ 3.0 METS) MET-hr/week. MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

SE = Standard Error; Std. Beta = Standardized Beta Coefficient.

Table 18. Moderation Analyses: Full Models Showing Significant Two-Way Interaction Effects on Past Week Leisure MVPA.

	$\hat{\beta}$	SE	Std Beta	R^2	R^2 Change	p value
Block 1				0.03	0.03	0.905
Age	0.239	0.44	0.06			
BMI	0.287	0.46	0.07			
$Income_2$	-6.11	7.15	-0.14			
$Income_3$	-7.43	8.13	-0.16			
$Education_2$	-2.19	5.75	-0.05			
$Education_3$	5.59	6.01	0.12			
Block 2				0.27	0.24	< 0.0001
Barrier Self-Efficacy	-16.63	12.73	-0.59			
Social Support Friends	-3.28	1.34	-1.47			
Access to Home Equipment	-4.70	4.63	-0.48			
Block 3				0.37	0.10	0.005
$SE_B \times SS_{FR}$	0.93	0.46	1.86			
$SE_B \times AC_H$	1.27	1.53	0.60			
Block 4						
$SE_B \times SS_{FR} \times AC_H$	0.01	0.03	0.20	0.37	0.00	0.715
Block 1				0.03	0.03	0.897
Age	0.17	0.42	0.04			
BMI	14.78	29.91	0.05			
$Income_2$	-7.37	7.05	-0.16			
$Income_3$	-7.22	7.92	-0.16			
$Education_2$	-1.39	5.79	-0.03			
$Education_3$	6.07	5.98	0.13			
Block 1				0.27	0.24	0.000
Barrier Self-Efficacy	-17.83	13.28	-0.64			
Social Support Friends	-3.64	1.33	-1.63			
Access to Facilities	-1.98	2.35	-0.43			
Block 2				0.36	0.09	0.010
$SE_B \times SS_{FR}$	1.16	0.39	2.32			
$SE_B \times AC_F$	0.53	0.75	0.51			
Block 3						
$SE_B \times SS_{FR} \times AC_F$	-0.00	0.01	-0.11	0.36	0.001	0.748

$Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree. SE_B =Barrier Self-Efficacy; SS_{FR} = Social Support Friends; AC_F = Access to Facilities; AC_H = Access to Home Equipment.

Past week leisure MVPA measured as moderate to vigorous (≥ 3.0 METS) MET-hrs/week. MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

SE = Standard Error; Std. Beta = Standardized Beta Coefficient.

Table 19. Regression Models to Predict Steps per Day Based on Barrier Self-Efficacy (X_1), for Nine Combinations of Levels of Access to Facilities and Social Support from Friends.

Level of Access and Social Support	**Regression Models**
Low Access Low Social Support	$\hat{Y} = 2145.70\ X_1 + 3814.16$
Low Access Moderate Social Support	$\hat{Y} = 1759.05\ X_1 + 5116.42$
Low Access High Social Support	$\hat{Y} = 1372.40\ X_1 + 6419.67$
Moderate Access Low Social Support	$\hat{Y} = 1597.69\ X_1 + 4682.47$
Moderate Access Moderate Social Support	$\hat{Y} = 1380.64\ X_1 + 5985.73$
Moderate Access High Social Support	$\hat{Y} = 1163.58\ X_1 + 7288.98$
High Access Low Social Support	$\hat{Y} = 1049.69\ X_1 + 5551.78$
High Access Moderate Social Support	$\hat{Y} = 1003.89\ X_1 + 6858.86$
High Access High Social Support	$\hat{Y} = 954.78\ X_1 + 8158.29$

X_1 = Barrier Self-Efficacy.

For Level of Access and Social Support: Low and High = Mean ± 1 SD; Moderate = Mean.

Table 20. Reduced Model Showing Significant Two-Way Interaction Effects on Past Year MVPA.

	$\hat{\beta}$	SE	Std Beta	R^2	R^2 Change	p value
Block 1				0.14	0.14	0.08
Age	0.32	0.97	0.35			
BMI	0.77	1.04	0.08			
$Income_2$	7.41	15.99	0.74			
$Income_3$	19.50	17.88	0.19			
$Education_2$	4.83	12.92	0.04			
$Education_3$	-21.71	12.79	-0.21			
Block 2				0.25	0.11	0.006
Barrier Self-Efficacy	-16.17	18.91	0.26			
Social Support Friends	-5.17	2.96	-1.04			
Block 3						
$SE_B \times SS_{FR}$	1.61	0.76	1.44	0.29	0.04	0.047

$Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree. SE_B = Barrier Self-Efficacy; SS_{FR} = Social Support Friends.

Past Year MVPA measured as average moderate to vigorous (≥ 3.0 METS) MET-hrs/week. MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

SE = Standard Error; Std. Beta = Standardized Beta Coefficient.

Table 21. Regression Models to Predict Past Year MVPA Based on Barrier Self-Efficacy (X_1), for Three Levels of Social Support from Friends.

Level of Social Support	**Regression Model**
Low Social Support	$\hat{Y} = 5.26 X_1 + 8.15$
Moderate Social Support	$\hat{Y} = 21.71 X_1 - 44.69$
High Social Support	$\hat{Y} = 38.17 X_1 - 97.53$

X_1 = Barrier Self-Efficacy

For Level of Social Support: Low and High = Mean ± 1 SD; Moderate = Mean.

Table 22. Reduced Model Showing Significant Two-Way Interaction Effects on Past Week Leisure MVPA.

	$\hat{\beta}$	SE	Std Beta	R^2	R^2 Change	p value
Block 1				0.03	0.03	0.905
Age	0.18	0.41	0.43			
BMI	0.25	0.44	0.06			
$Income_2$	-8.01	6.85	-0.18			
$Income_3$	-8.13	7.66	-0.18			
$Education_2$	-2.46	5.54	-0.05			
$Education_3$	4.15	5.48	0.09			
Block 2					0.24	< 0.0001
Barrier Self-Efficacy	-11.73	8.10	-0.42			
Social Support Friends	-3.43	1.27	-1.54	0.26		
Block 3						
$SE_B \times SS_{FR}$	1.07	0.34	2.15	0.35	0.09	0.002

$Income_2$ = \$50,000-99,999; $Income_3 \geq$ \$100,000; $Education_2$ = Associate's to Bachelor's Degree; $Education_3 \geq$ Post Graduate Degree. $AC_F = SE_B$ = Barrier Self-Efficacy; SS_{FR} = Social Support Friends.

Past week leisure MVPA was measured as moderate to vigorous (≥ 3.0 METS) MET-hrs/week. MET-hr/wk was calculated by multiplying hr/wk by metabolic cost of each activity.

SE = Standard Error; Std. Beta = Standardized Beta Coefficient.

Table 23. Regression Models to Predict Past Week Leisure MVPA based on Barrier Self-Efficacy (X_1), for Three Levels of Social Support from Friends.

Level of Social Support	**Final Regression Model**
Low Social Support	$\hat{Y} = 2.51\ X_1 - 12.34$
Moderate Social Support	$\hat{Y} = 13.45\ X_1 - 47.40$
High Social Support	$\hat{Y} = 24.39\ X_1 - 82.45$

X_1 = Barrier Self-Efficacy

For Level of Social Support: Low and High = Mean ± 1 SD; Moderate = Mean.

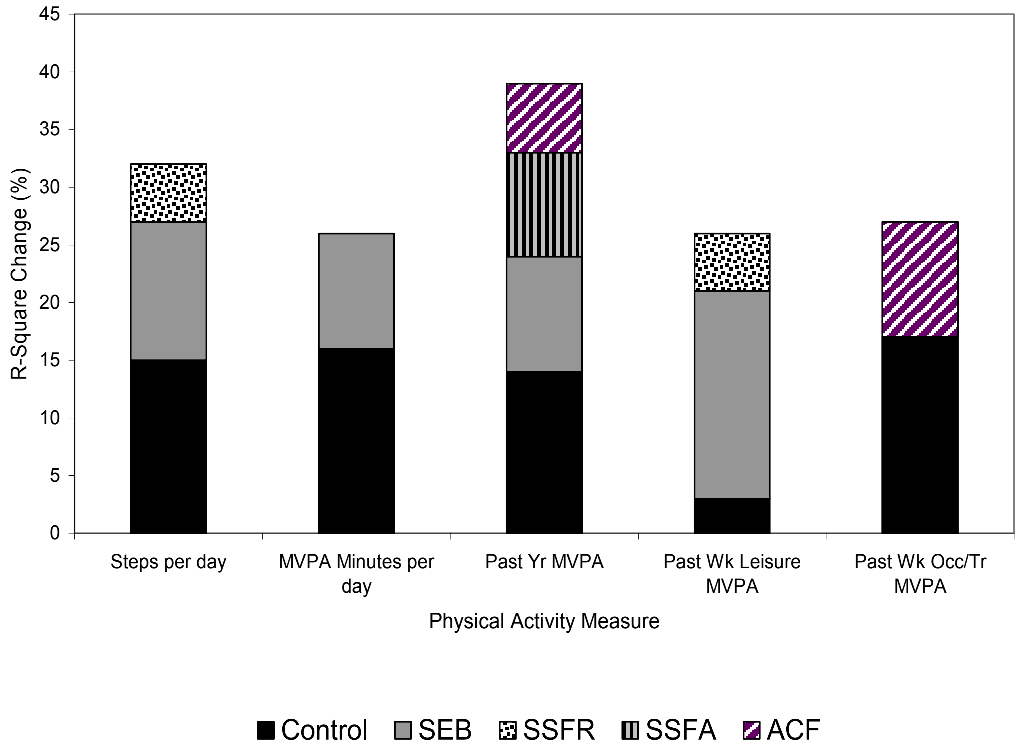

Figure 3. R^2 Change (%) Associated with the Addition of Each Significant Independent Predictor with the Five Physical Activity Outcome Variables, Based on Stepwise Linear Regression Analysis.

MVPA = Moderate to Vigorous Physical Activity; Control = Control Variables (age, BMI, income, education); SE_B = Barrier Self-Efficacy; SS_{FR} = Social Support Friends; SS_{FA}= Social Support Family; AC_F = Access to Facilities.

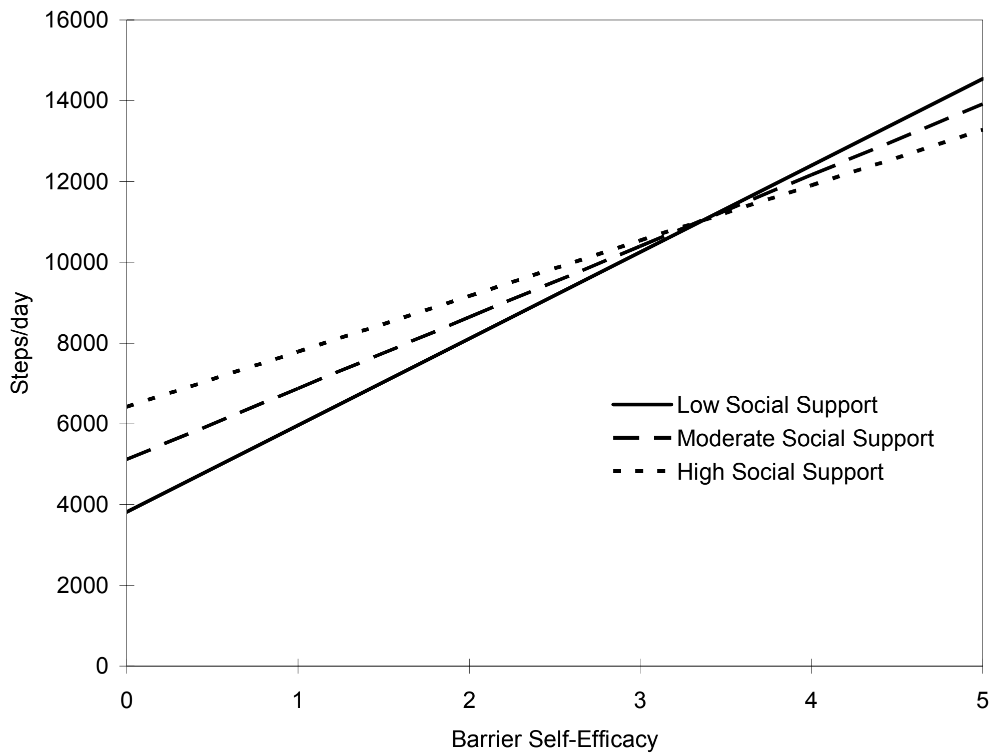

Figure 4. Steps per Day among Women with Low Access to Facilities at Three Levels of Social Support from Friends.

Low and High = Mean ± 1 SD and Moderate = Mean, based on the final moderation analysis regression model.

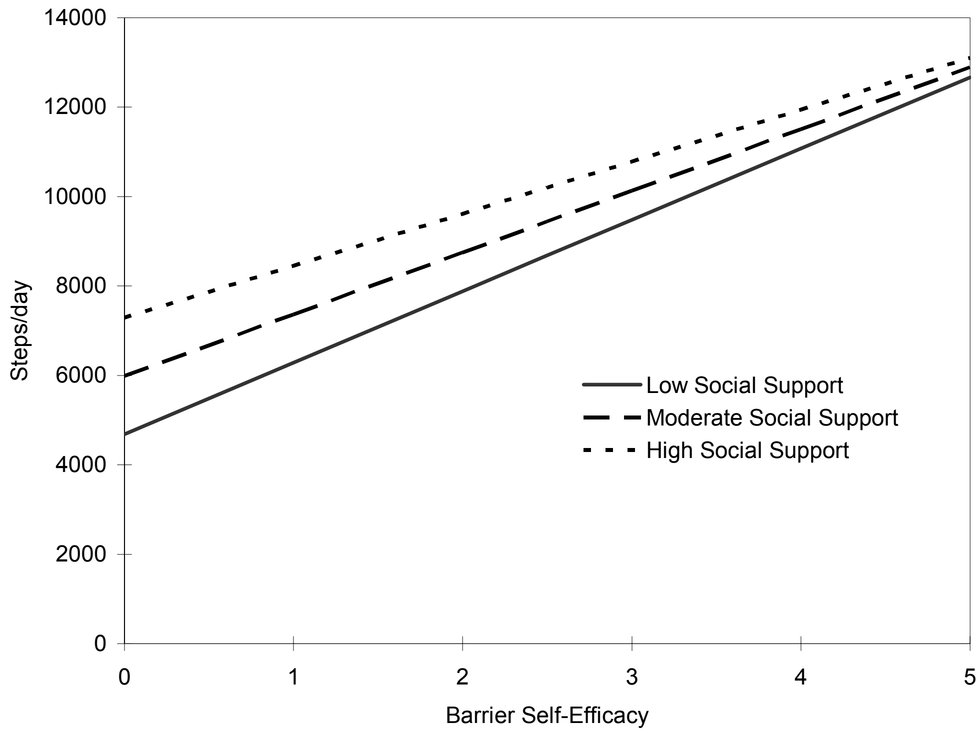

Figure 5. Steps per Day among Women with Moderate Access to Facilities at Three Levels of Social Support from Friends.

Low and High = Mean ± 1 SD and Moderate = Mean, based on the final moderation analysis regression model.

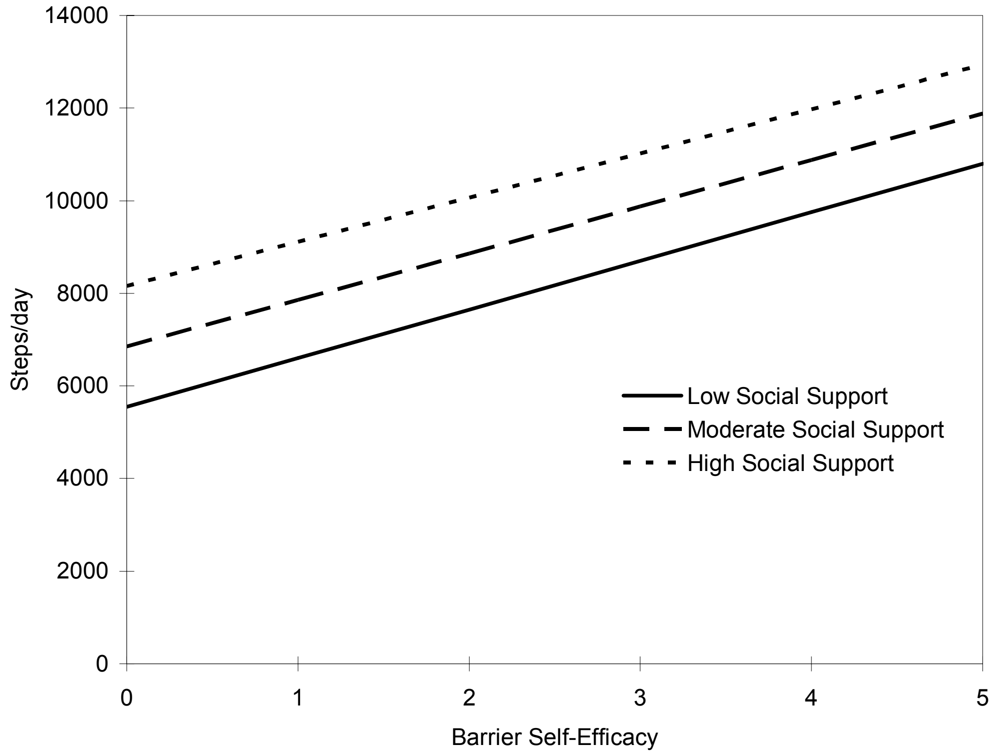

Figure 6. Steps per Day among Women with High Access to Facilities at Three Levels of Social Support from Friends.

Low and High = Mean ± 1 SD and Moderate = Mean, based on the final moderation analysis regression model.

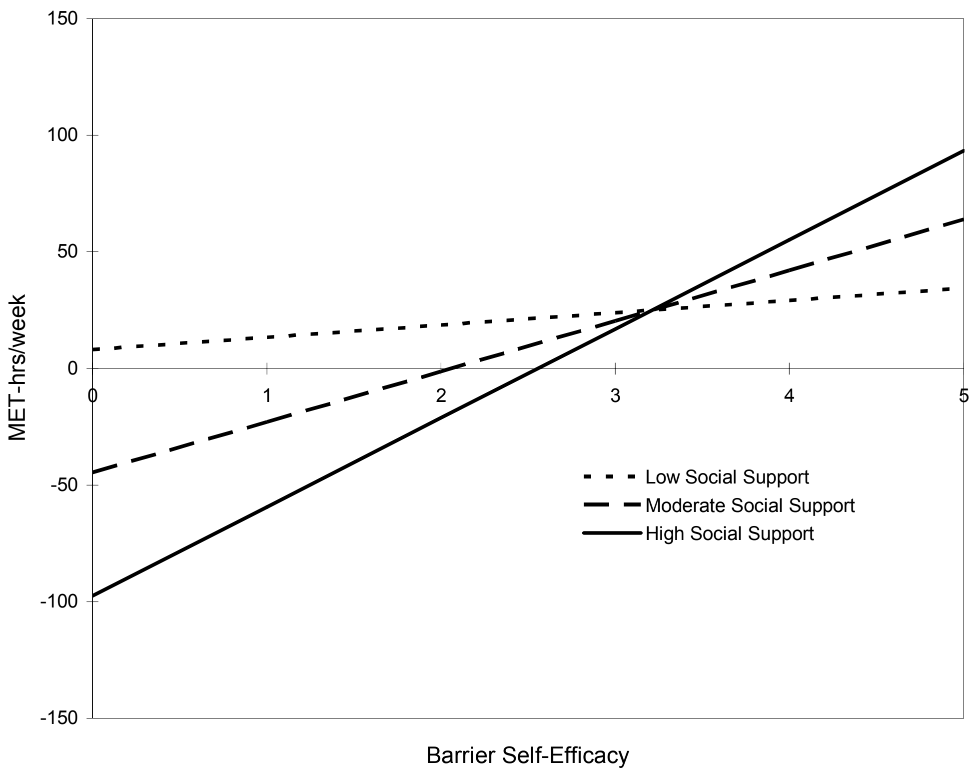

Figure 7. Past Year MVPA among Women at Three Levels of Social Support from Friends.

MVPA = Moderate to Vigorous Physical Activity.

Low and High = Mean ± 1 SD and Moderate = Mean, based on the final moderation analysis regression model.

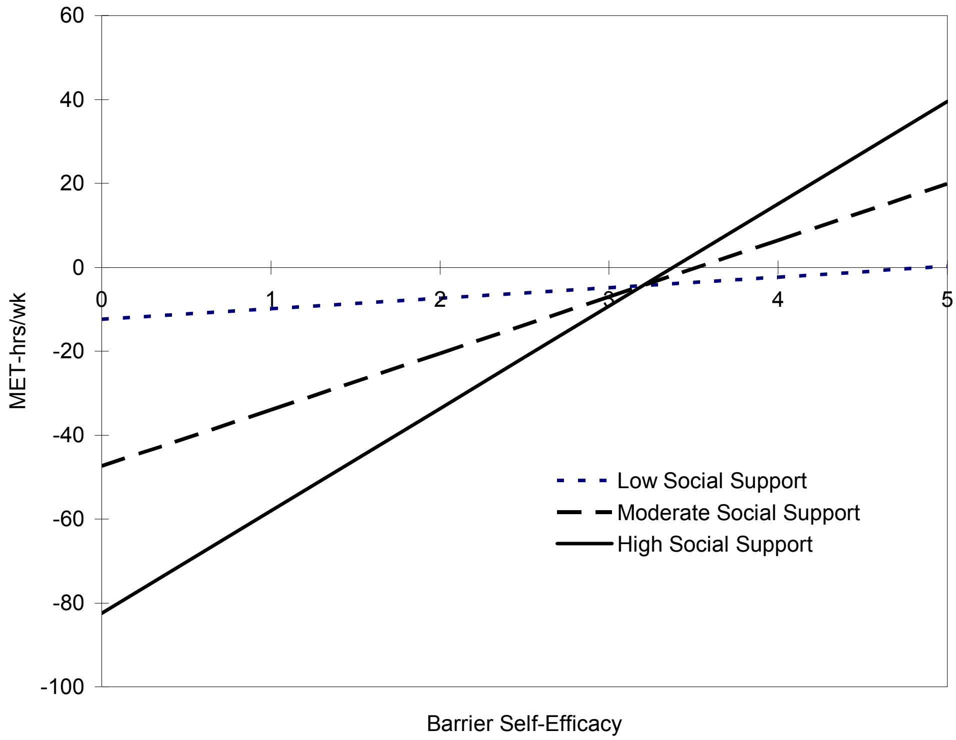

Figure 8. Past Week Leisure MVPA among Women at Three Levels of Social Support from Friends.

MVPA = Moderate to Vigorous Physical Activity.

Low and High = Mean ± 1 SD and Moderate = Mean, based on the final moderation analysis regression model.

CHAPTER V

DISCUSSION

Understanding factors associated with physical activity in the perimenopausal and postmenopausal population is a key step in physical activity promotion in this group of women. The present study is unique in that it contributes to the current understanding of determinants of physical activity behaviors among peri- and postmenopausal women in three ways. First, utilizing a multi-dimensional perspective of physical activity behavior framed by Social Cognitive Theory (SCT), this study investigated the individual, perceived social, *and* perceived environmental factors associated with physical activity.

Second, the reciprocal nature of SCT was recognized by studying the direct and indirect relationships between the individual, perceived social, and perceived environmental determinants of physical activity. This was examined by employing moderation-mediation analysis, which allowed examination of the interaction effects and confounding effects of social cognitive variables on physical activity.

Third, this study utilized a multi-dimensional perspective of physical activity. This was achieved by using several outcome measures of physical activity and assessing activity objectively (via pedometer) and subjectively (via Modifiable Activity Questionnaire). Measuring physical activity both objectively and subjectively provided a means to examine the determinants of physical activity based on volume (steps per day); moderate to vigorous intensity (MVPA minutes per day, past year MVPA, past week leisure MVPA, and occupational/transport MVPA); domain (total, leisure, occupational/ transport); and over time (past week and past year). In addition, because the objective and subjective physical activity data were consistent, and the levels of activity reported by the women in this study were similar to other studies that employed MAQ and pedometer-based data (Conroy et al., 2007; Kriska et al., 2006; Neuman et al., 2009), this study might advance the current understanding of total activity MVPA in peri and postmenopausal women. MVPA is of particular interest when aiming to promote activity for prevention of OP among women because MVPA has been shown to be associated with increased BMD in this population. (Borer et al., 2007; Greendale et al., 2003; Kemmler et al., 2003; Yamazaki et al., 2004).

The multi-dimensional approach employed in this study may allow a more comprehensive understanding of physical activity behavior in peri- and postmenopausal women. This may, in turn, provide valuable information for researchers, practitioners, and public health officials aiming to promote physical activity among this group of women. The information provided in this study may also allow these groups to understand factors important for promoting activity at moderate to vigorous intensity, which is critical for bone health and prevention of diseases like OP. In order to shed light on the physical activity behavior of peri- and postmenopausal women, this chapter will discuss the results of this study with respect to each specified research aim. This will be followed by an overall summary of the study findings and discussion of the implications of these findings. This chapter will conclude with study limitations and recommendations for future research.

Research Aim 1

The purpose of the first research aim was to describe social cognitive factors associated with the MVPA of peri- and postmenopausal women. Few physical activity determinants studies have examined relationships between multi-dimensional social cognitive factors with several dimensions of physical activity assessed objectively and subjectively (Conroy et al., 2007; Tudor-Locke & Meyers, 2001). Further, according to SCT, determinants that are of importance differ by population and behavior (Bandura, 1978; 2004). This indicates the nature and strength of the relationships between the social cognitive variables and physical activity behavior found in this study may be unique to peri- and postmenopausal women and the physical activity domain.

Based on the findings of the bivariate correlation analysis, the associations between social cognitive variables differed based on physical activity outcome. For steps per day, MVPA minutes per day, and past week leisure MVPA, significant associations were found with barrier self-efficacy, task self-efficacy, access to home-equipment, and social support from family and friends. These associations provide support for each of these social cognitive variables as correlates of objectively measured past week physical activity and subjectively measured past week leisure activity. Of all of the social cognitive independent variables included in this study, barrier self-efficacy emerged as the most prominent correlate, exhibiting the strongest association with steps per day ($r = 0.40$), MVPA minutes per day ($r = 0.45$), and past week leisure MVPA ($r = 0.43$). Self-efficacy is a significant physical activity determinant that consistently emerges in the literature (Dishman et al., 1985; Trost et al., 2002), supporting the results of this bivariate analysis. Further, the presence and strength of the relationships between barrier self-efficacy and physical activity were in line with findings by Resnick and Nigg (2003) and Brassington et al. (2002), who indicated barrier self-efficacy was strongly associated with physical activity ($r = 0.50$ and $r = 0.46$) among middle aged to older adults. These associations may mean that women’s perceived capabilities for exercising in the face of barriers is most strongly reflective of their actual total physical activity when it is measured objectively, as well as their MVPA when measured objectively and subjectively.

For past year MVPA, significant associations were also found with barrier self-efficacy, task self-efficacy, social support from family, social support from friends, and access to home equipment. Interestingly, perceived social support from family demonstrated the strongest bivariate association with past year MVPA, followed by barrier self-efficacy. This may indicate that social support is particularly important for MVPA performed over a longer time period (i.e. the past year). These findings are consistent with those by Sternfeld et al. (1999), who indicated social support was a significant predictor of MVPA performed in the leisure domain, as well as with those findings reported by McAuley et al. (2003), who indicated self-efficacy and social support were related to higher levels of long-term physical activity ($r = 0.42$, $r = 0.23$).

In terms of occupational/transport MVPA, the bivariate analysis indicated an inverse association with access to facilities. This finding could be due to the fact that higher levels of occupational activity may be performed in areas where access to facilities tends to be lower (i.e., rural). Few studies have examined determinants of occupational/ transport activity, and those studies that have done so have reported no significant results (Newman et al., 2009). However, it could be that women who perform more occupational activity on a daily basis may live or work in areas where access to facilities is low.

Overall, the results of the bivariate analysis indicate each of the social cognitive variables was significantly associated with one or more measures of physical activity in peri- and postmenopausal women. This supports the use of these social cognitive variables in understanding factors that are associated with physical activity, which is consistent with existing literature (Dishman et al., 1995; Trost et al., 2002). This bivariate analysis, however, does not consider the combined effects of each of these social cognitive variables with each physical activity outcome, a shortcoming that is addressed through Research Aim 2.

Research Aim 2

The second aim of this study was to use stepwise linear regression analysis to identify the amount of variance explained by the social cognitive variables for each of the physical activity outcome measures. The following includes a discussion of the models derived for each of the physical activity outcome measures.

MVPA Minutes per Day

For MVPA minutes per day, above and beyond age, BMI, income, and education, barrier self efficacy was the only social cognitive independent variable to enter the model. For this measure of MVPA, barrier self-efficacy explained 10% of the variance. Collectively, these variables explained 16% of the variance in MVPA minutes per day. This finding was in line with that of Estok et al. (2007) and Swaim et al. (2008) who found self-efficacy explained 16% and 13% of the variance in weight bearing physical activity in postmenopausal women, respectively. Additionally, other researchers have studied factors that tend to impede physical activity in middle to older-aged women (i.e. barriers). Significant barriers that have been reported in qualitative studies included lack of time, care giving duties, and fatigue (King et al., 2000; Thompson et al., 2002). Because the present study employed a barrier self-efficacy questionnaire that included each of the barriers noted by King et al. (2000) and Thompson et al. (2002), such barriers were likely to be associated with physical activity in this study. Therefore, it was expected that higher levels of self-efficacy to overcome these barriers might explain a significant portion of the variance in physical activity. According to Sternfeld et al. (1999) who reported those with higher self-efficacy were six times more likely to engage in sport and exercise, self-efficacy may be particularly important for past week moderate to vigorous activity that tends to be performed in the exercise/leisure domain.

Steps per Day and Past Week Leisure MVPA

One finding reflected through the stepwise regression analysis was that the social cognitive variables that entered the models were different based on the measure of physical activity. For instance, with MVPA minutes per day described above, barrier self-efficacy was the only social cognitive variable to enter the model. However, for steps per day, barrier self-efficacy entered the regression model first, followed by social support from friends, explaining 12% and 5% of the variance in activity, respectively. These findings were similar for past week leisure MVPA, where barrier self-efficacy entered the regression model first, followed by social support from friends. For past week leisure MVPA, these variables explained 18% and 5% of the total variance in activity, respectively.

For both steps per day and past week leisure MVPA, the role of barrier self-efficacy in explaining the largest portion of the variance in activity was not a surprising finding. As described above for MVPA minutes per day, the barriers women in this study face on a daily basis may influence physical activity, and women's ability to overcome those barriers has been shown to explain a significant portion of the variance physical activity over a six month timeframe ($R^2 = 0.21$) (Brassington et al., 2002)

The entrance of social support from friends entering the steps per day and past week leisure MVPA models was not as clear cut. Relative to other social cognitive variables in this study, social support from friends exhibited a slightly weaker bivariate association with both physical activity outcome variables ($r = 0.23$) (Table 12). However, previous research supports the finding that higher levels of self-efficacy and social support are the most significant determinants of physical activity in the leisure domain when self-efficacy, social support, and access are assessed (Giles-Corti & Donovan, 2002; Sternfeld, 1999). Additionally, both barrier self-efficacy and social support have been shown to collectively explain 25% of the variance in women's total physical activity performed specifically for OP prevention in middle to older-aged women (Hseih et al., 2008). This was consistent with the present study, where, together, self-efficacy and social support explained 17% of the variance in steps per day and 23% of the variance in past week MVPA.

Past Year MVPA

In addition to self-efficacy and social support, perceived access to facilities has also been shown to be an important determinant of physical activity behavior (Booth et al., 2000). For instance, Blanchard et al. reported significant associations for physical activity with self-efficacy, social support and access to facilities; and when these variables were considered together, they explained 15% of the variance in physical activity. The results of the present study supported this previous research, where for subjectively measured past year MVPA, social support from family, barrier self-efficacy, and access to facilities entered the model, explaining 9%, 10%, and 6% of the variance in physical activity, respectively. These relationships were detected after controlling for age, BMI, income, and highest level of education. Therefore, for past year MVPA, it appears social support emerged as a very important determinant of physical activity, along with barrier self-efficacy, and access to facilities. This may be helpful when trying to promote MVPA over longer periods of time, which could be especially beneficial for bone health.

In terms of the relative importance of the variables that entered the model for past year MVPA, the results of this study were unexpected. Contrary to the findings of Giles-Corti and Dononvan (2002) who found individual level factors influenced physical activity at a level that was two times greater than the influence of social support on physical activity, the present study found social factors to play a much more significant role in predicting activity. However, Giles-Corti and Donovan (2002) measured moderate to vigorous and ambulatory activity performed over the past two weeks, while the present study found social support to be of greatest importance for past *year* MVPA. It could be that support from family becomes more important for regular participation in MVPA over time. Further, the positive relationship between social support and physical activity has been reported among women and older adults, where those who had higher levels of social support were two times more likely to engage in higher amounts of activity (Eyler et al., 1999; Resnick et al., 2002).

Occupational/Transport MVPA

Most physical activity research focuses on physical activity performed in the exercise, sport, or leisure domain. However, in their traditional roles, women may perform a large portion of their activity in or outside of the home (Ainsworth, 2000). In order to address this, the present study measured and analyzed past week occupational/ transport MVPA separately from past week leisure MVPA. Results indicated that after age, income, education, and BMI were entered into the model, access to facilities was the only social cognitive variable to enter the model, explaining 10% of the variance in physical activity. An examination of the beta weight associated with access to facilities ($\beta = -9.81$) indicates the nature of this relationship is inverse. This may indicate that lower access to facilities is associated with higher occupational activity, which is consistent with bivariate associations reported in this study. It may be the case that higher levels of occupational activity are performed in rural environments, or by individuals who reside in rural environments, where access to physical activity facilities is lower. However, few studies have measured occupational activity in this way, and in existing studies where determinants of occupational activity were examined, no significant findings were reported (Newman et al., 2009).

Overall, one consistent finding that emerged through the regression analyses was that barrier self-efficacy entered four of the five models, including steps per day, MVPA minutes per day, past year MVPA, and past week leisure MVPA. In addition to barrier self-efficacy, social support also explained a significant portion of the variance in steps per day and past week leisure MVPA. Moreover, social support from family and access to facilities also entered the model for past year MVPA. This indicates that self-efficacy, social support, and access may be important for promotion of physical activity, but their relative importance may differ based on the physical activity outcome of interest. However, when more than one of these variables enters a physical activity model, as is the case in the present study, indirect relationships may exist between these variables (Lewis et al., 2002; Resnick et al., 2002); a possibility that will be addressed through Research Aim 3.

Research Aim 3

The third and final aim of this research study was to determine if significant interaction (moderation) effects or confounding (mediation) effects existed between independent variables on each physical activity outcome variable. The moderation-mediation analysis conducted in this study was novel in that, not only were the three dimensions of the SCT represented through the six social cognitive variables used in this study, the analyses were conducted for five physical activity measures. Through these analyses, results indicated a significant three-way interaction effect existed for steps per day, and two-way interaction effects existed for past year MVPA and past week leisure MVPA.

Moderation

Steps per Day

The significant three-way interaction between barrier self-efficacy, social support from friends, and access to facilities was a unique finding in this study. The nature of these relationships indicated that, regardless of level of access to facilities and level of social support, an increase in barrier self-efficacy was associated with an increase in steps per day.

Closer examination of the interactions between barrier self-efficacy and steps per day, at three levels of social support from friends, within each of three levels of access to facilities, revealed some interesting relationships. For low, moderate, and high levels of access, an increase in barrier self-efficacy was associated with the largest increase in steps per day for those women with lower levels of social support (when compared to women with moderate or high levels of social support). A comparison of slopes between each level of access revealed this increase was greatest for women with lower levels of access (versus moderate or high levels of access).

The finding that an increase in barrier self-efficacy was associated with the largest increase in steps per day for those with lower levels of social support, regardless of level of access, is a concept that has been indirectly supported by other researchers. For instance, Spence and Lee (2003) and Vrazel et al. (2008) hypothesized that that enhancement in factors closest to the individual (e.g. barrier self-efficacy) may help to "buffer" the negative affect that factors outside of the individual (e.g. low levels of social support or low access to facilities) may have on physical activity. The simultaneous examination of these factors in the present study indicated an increase in barrier self efficacy is important for steps per day, and it may be especially important for women with lower levels of social support and low levels of access to facilities. In other words, all women might benefit from enhancement in barrier self-efficacy, but this may be particularly true for women without "all of the advantages" of access and support.

Overall, the three-way interaction indicates that among women with low, medium and high access to facilities and social support, an increase in barrier self-efficacy is associated in an increase in steps per day. Therefore, access and social support may moderate the association between barrier self-efficacy and steps per day. This substantiates the importance of barrier self-efficacy, but its relative importance differs depending on level of access to facilities and social support from friends, where this study indicates it is most important for women with low social support and low access. The three-way interaction effect also supports the interplay between the person, environment, and behavior emphasized by the SCT, where a change in one factor may impact the relationships between other factors in the model (Bandura, 1997).

Though few physical activity determinants studies have reported a three-way interaction effect, interaction effects between self-efficacy and social support, and self-efficacy and access were reported by Blanchard et al. (2005), supporting the results of this study. This finding was also partly supported by the results of Cerin et al. (2008) who found interaction effects between self-efficacy and access with physical activity. Additionally, a multi-level intervention study by Brownson et al. (2005) demonstrated a positive trend in walking activity and moderate physical activity among adults in rural communities when self-efficacy, social support, and access were targeted. The evidence provided by previous studies and the present investigation indicates barrier self-efficacy, social support from friends, and access to facilities should be considered as relevant components of health promotion efforts aimed at increasing total ambulatory physical activity in peri- and postmenopausal women.

Past Year MVPA and Past Week Leisure MVPA

Significant two-way interactions for barrier self-efficacy and social support from friends were found for both past year MVPA and past week leisure MVPA. Results indicated that at each level of social support, an increase in barrier self-efficacy was associated with an increase in activity. Closer examination of these relationships revealed that at higher levels of perceived social support from friends, the relationship between barrier self-efficacy and each MVPA measure increased. These findings indicate the indirect relationship between social support and barrier self-efficacy, in that social support moderates the association of barrier self-efficacy with both past year MVPA and past week leisure MVPA. This confirms the conclusions of other studies that indicated indirect relationships exist between these two variables on physical activity (Hseih et al., 2008; McAuley et al., 2003; Resnick et al., 2002). In general, this also supports the inter-relationships fundamental to the SCT (Bandura, 1997; 1998), providing evidence for the importance of both barrier self- efficacy and social support from friends on the MVPA of peri- and postmenopausal women.

A comparison of the magnitude of the slopes for the interaction effects between past year MVPA and past week leisure MVPA revealed the moderating relationships were slightly stronger for past year MVPA than for past week leisure MVPA (both measured in MET-hrs/week). This is a unique aspect of this study, as this analysis indicated the nature of the moderating effects of social support on self-efficacy was similar for both measures of physical activity. However, the strength of the moderating effects differed based on the dimension of physical activity measured. In general, it appears the level of social support moderates the association between self-efficacy and physical activity. However, it may be slightly more important for MVPA performed over the past year as opposed to the past week. This could indicate that social support has a slightly larger impact on average weekly MVPA performed over the past year than it does on leisure MVPA performed over the past week. Overall, these findings demonstrate that both self-efficacy and social support are important determinants of past year MVPA and past week leisure MVPA among peri- and postmenopausal women, and therefore should be considered in efforts aiming to promote MVPA for prevention of OP or other desired health outcomes where intensity of activity is relevant.

Mediation

Results of the mediation analysis indicated one significant relationship, where social support from family confounded the effect of barrier self-efficacy on past year MVPA. The nature of this confounding relationship was that when social support from family entered the model, the relationship between barrier self-efficacy and past year MVPA decreased. The decrease in the relationship between barrier self-efficacy and activity indicates that when social support from family is considered, the influence of barrier self-efficacy on physical activity is not as prominent. This supports the findings of previous studies that indicate an indirect relationship between self-efficacy and social support on physical activity (McAuley et al., 2003; Resnick et al., 2002). Similar to that discussed for moderation analysis, these findings add support to the notion that both self-efficacy and social support should be taken into consideration in efforts aiming to promote MVPA of peri- and postmenopausal women.

Summary of Findings

Several important findings were revealed in this study. First, this investigation provided support for the use of SCT in examining individual, perceived social, and perceived environmental factors that are important for women's physical activity participation. Barrier and task self-efficacy, social support from family and friends, and access to home equipment were found to be directly associated with several measures of physical activity.

Second, this study indicated the social cognitive factors that were most important, when considered together, varied based on the physical activity outcome measure of interest. This highlighted the importance of not only considering the multi-dimensional nature of social cognitive factors associated with physical activity, but it also emphasized the importance of considering the multi-dimensional nature of physical activity. This means the factors important for physical activity may be different when activity is measured in terms of volume (steps per day), intensity (MVPA), over time (past week or past year), or within specific domains (total, leisure, occupational/transport). This is relevant because, depending on the desired health outcome (i.e., promoting MVPA for bone strength), the targets of an intervention or health promotion program may be unique to the type of physical activity known to lead to that particular health outcome. A deeper understanding of determinants of specific dimensions of physical activity could be very important for promoting activity in a way that will elicit the ideal physiological response (Brownson et al., 2005). In the context of this study, this would mean promoting MVPA to stimulate bone building responses or preservation of bone (Hagberg et al., 2001; Lanyon, 1996; Nelson et al., 1994; Stengel et al., 2005).

Third, this study demonstrated the *indirect* relationships between social cognitive factors and physical activity, and that these indirect relationships differed based on physical activity outcome. This study emphasized the importance of the interacting effects of self-efficacy, social support, and/or access on physical activity, as well as the confounding effects of self-efficacy and social support. However, the nature and strength of these relationships varied by type of activity performed. The present study demonstrated enhancements in barrier self-efficacy may be important for increasing physical activity, and this may be especially important for those with lower access and/or lower social support. Further, if this information is used to inform intervention research, due to the interacting relationships between each factor and the reciprocal nature of the SCT, the possibility that a change in social support and/or access may cause a change in the relationship between self-efficacy and activity should be considered.

While all social cognitive factors were directly and indirectly associated with physical activity to some degree, barrier self-efficacy continually emerged as a very important determinant for almost all physical activity outcome measures. In addition to barrier self-efficacy, social support also continually emerged for steps per day, as well as MVPA over the past year and past week. Though barrier self-efficacy and social support tended to be most predictive of physical activity among peri- and postmenopausal women, access was also found to be an important predictor of activity. Because the inclusion of access as a potential determinant of physical activity is a relatively new approach in physical activity research (Blanchard et al., 2005; Cerin et al., 2007; Giles-Corti & Donovan, 2002; Humpel et al. 2004), this study provided additional evidence for the inclusion of access, along with self-efficacy and social support, in studying direct and indirect factors associated with total activity and MVPA behaviors in peri- and post-menopausal women. This information could be used to inform physical activity interventions aiming to enhance health and/or reduce OP risk in this population.

Implications of Findings

These findings have some important implications for researchers and practitioners. Researchers should consider using the multi-dimensional SCT to guide their research aiming to understand peri- and postmenopausal women's physical activity behaviors. Not only does this multi-dimensional approach reflect the nature of the SCT, but it also might reflect the complex individual and social issues facing peri- and postmenopausal women. Additionally, this is in line with the conclusions made by other researchers using multi-dimensional approaches to understand determinants of physical activity (Booth et al., 2000; Giles-Corti & Donovan, 2002; Humpel et al., 2003) or to intervene on physical activity in community-dwelling adults (Brownson et al., 2005). Researchers should also examine these social cognitive factors in accordance with specific physical activity outcome measures. Much past determinants research has only focused on one dimension of physical activity, but as this study demonstrates, factors important for physical activity differ between physical activity dimensions such as total activity, MVPA, and MVPA within leisure and occupational/transport domains.

Practitioners may also be able to incorporate findings from this study, which provided strong support for considering self-efficacy, social support, and/or access when designing interventions aiming to promote physical activity in peri- and postmenopausal women; the specific combination of which may be different for desired dimension of activity and health outcome. Additionally, when designing health promotion programs, it may be helpful to consider the relative importance of each of these social cognitive factors. This may inform how resources needed to enhance each of these social cognitive factors could be optimally allocated based on the physical activity outcome of interest in peri- and postmenopausal women.

Applying the results of this study for prevention of osteoporosis where MVPA is of importance, barrier self-efficacy, social support from family and friends, and access to facilities could be targeted. Tailored approaches could be used to help women identify and develop plans for overcoming personal barriers to physical activity, which has shown promise in previous intervention research (Brassington et al., 2002; Piasau et al., 2002). This could be approached by enhancing personal mastery experiences, vicarious experiences, encouragement or persuasion, imaginal experiences, and physiological and emotional states (Bandura, 1997; Maddux, 1995). Family members and/or friends could be included in the intervention to enhance perception of support. For instance, provision of informational or emotional support might be especially helpful, as they have been shown to be associated with physical activity in women (Eyler, 1999). More emphasis could be placed on enhancing this support in longitudinal studies, which is reflective of the importance of social support in past year MVPA. Access to facilities could be addressed by offering community-based opportunities for physical activity, which has shown to be a promising target in a previous community intervention (Brownson et al., 2005). Moreover, the possibility of indirect associations between each of these factors should also be recognized. For instance, if enhancing long-term access is not possible due to associated costs, the potential of social support or self-efficacy buffering lower levels of access should be considered. Likewise, if perceived social support changes over time, this may influence the way in which changes in barrier self-efficacy influence MVPA. These temporal issues were noted in the multi-level intervention by Brownson et al. (2005) as possible causes for their lack of significant findings that should be addressed in future research.

Limitations

Like most studies, this study had several limitations that need to be addressed. First, this study consisted of a relatively homogeneous group of Caucasian, Midwestern women. Over 70% of the women had at least earned the equivalent of an Associate's degree, with nearly 40% having a post-graduate degree. Additionally, women who volunteer for physical activity research studies may be more interested in physical activity and research in general. For these reasons, the women who took part in this study may not be representative of the general peri- and postmenopausal population.

Second, while every attempt was made to confirm the results of this study through parallel non-parametric approaches, the slight non-normal distribution of the social support from friends variable may have caused some misleading interpretations. To that end, even though an acceptable significance criterion was established, some of the other relationships reported in this study may have occurred due to chance.

The third limitation pertains to the pedometer-based physical activity measures used in this study. While the pedometer used in this study provided a cost-effective way to assess total and moderate to vigorous ambulatory activity in one day epochs, the use of more precise, advanced technology such as accelerometers may have provided a more accurate picture of how physical activity changed throughout the day.

Finally, cross-sectional investigations are advantageous in that they are a cost-effect and time-efficient; however, causal inferences cannot be made. Additionally, both behavioral determinants and physical activity are known to fluctuate over time and by season. A longitudinal investigation may have allowed deeper understanding of the changes in determinants and physical activity patterns over time. Additionally, in terms of the physical activity measures being reflective of "usual" activity, it was observed that differences existed between the women's subjective report of what they did for MVPA over the week as compared to MVPA measured objectively over the same week. This may be reflective of temporal changes in barriers (i.e., an especially busy week), support (i.e. husband was traveling or exercise partner was sick), or environment (i.e., weather or change in daylight hours) that may occur when a "snapshot" of physical activity is used as the outcome measure. Awareness of these and other potential research limitations not only aids in the interpretation of results of the present study, but it may also be helpful for researchers aiming to conduct similar future investigations.

Recommendations for Future Research

This study provided evidence to support the use of SCT as a framework by which we might understand and describe the physical activity behaviors of peri- and postmenopausal women. Specific social cognitive factors were selected for this study based on the strength of relationships found in the literature. However, there are many other social cognitive variables that could be examined with regard to the peri- and postmenopausal population, such as knowledge, enjoyment, or social support from health care professionals. Additionally, based on resource limitations, the present study consisted of a relatively small sample size. Although this allowed for face-to-face data collection to take place, a larger sample size may allow more advanced statistical analyses to be conducted such as structural equation modeling. This could lead to detection of other relationships that might exist between social cognitive variables and physical activity. Further, due to the fact that temporal changes in behaviors and causal inferences cannot be made based on cross-sectional investigations, a longitudinal study may help identify cause-effect relationships and temporal fluctuations in social cognitive factors and physical activity behaviors over longer periods of time.

One unique aspect of this study was that occupational/transport activity was included as a physical activity outcome measure. The cause of the indirect relationship between access to facilities and past week occupational activity, however, was not fully understood, and should be investigated through future research. For instance, it is unlikely that lower access to facilities caused higher levels of occupational activity. Instead, this was likely due to circumstances such as residence or occupation in rural areas where access to facilities is lower. Therefore, future research might investigate this issue further in order to better understand the physical activity behaviors of rural and urban peri- and postmenopausal women.

Finally, a similar study employing both quantitative and qualitative research methods may help researchers and practitioners understand *why* particular determinants of physical activity are important or interact with each other. Additionally, qualitative studies may lead to the emergence of additional or unique factors important for the study of women's physical activity. Researchers and practitioners may then be able to incorporate these factors into approaches aiming to further understand or promote physical activity among peri- and postmenopausal women.

APPENDIX A

DEMOGRAPHIC AND HEALTH INFORMATION QUESTIONNAIRE

PARTICIPANT DEMOGRAPHIC AND HEALTH INFORMATION QUESTIONNAIRE

Age (in years): ___ ___

Height without shoes: ___(ft) ___ ___(in)   Weight without shoes: ___ ___ ___(lb)

For each item, please place an **"X"** next to the response that best describes you.

1) Race

___Black or African American
___Hispanic or Latino
___White
___Asian American
___American Indian or Alaskan Native
___Multi-racial
___Other

2) Marital Status

___Never Married
___Widowed
___Divorced
___Separated
___Partnered
___Married

3) Number of children

___0
___1
___2
___3
___4
___5+

4) Household annual income ($)

___<24,999
___25,000-34,999
___35,000-49,999
___50,000-74,999
___75,000-99,999
___100,000+

5) Highest level of education completed

___High school, no diploma
___High school diploma or GED
___Some post high-school (no degree)
___Associates degree
___Bachelors degree (BA, BS, BBA)
___Post graduate degree

6) Smoking status
___Never smoked
___Former smoker
___Smoke some days
___Smoke every day

7) Typical servings of alcohol per week
(1 serving = 12oz. beer, 5oz. glass of wine, or a drink with 1 shot of liquor)

___0
___1-2
___3-4
___5-6
___7+

8) Menopausal Status

___Irregular menstrual cycles or no menstrual periods **for less than one year**
___No menstrual periods **for one year or more**

9) Have you had your uterus removed (complete/total, partial, or radical)

___No (Skip to Question 10)
___Yes (Please answer Question 9b)

If you answered yes to Question 9, please answer the following Question 9b.

9b) When you had a hysterectomy, how many ovaries were removed?

___0
___1
___Both
___Don't Know

10) Have you ever taken estrogen (ERT) or estrogen combined with progestin (HRT) for 3 months or more?

___No
___Yes, within the last 5 years but not currently
___Yes, currently

11) Have you ever taken corticosteroids, such as cortisone and prednisone, for 3 months or more?

___No
___Yes, within the last 5 years but not currently
___Yes, currently

12) Has your physician or other health care provider ever diagnosed you with any of the following conditions? (**place and "X" next to all that apply**):

___Asthma or other lung disease
___Cardiovascular (heart) disease
___Cancer (breast, bone marrow)
___Celiac or Inflammatory Bowel Disease (IBD)
___Diabetes
___Epilepsy
___Thyroid disease
___Bone disease
___Rheumatoid Arthritis

13) Has a biological parent been diagnosed with osteoporosis or a hip or spine fracture?

___No
___Yes

APPENDIX B

CALCIUM AND VITAMIN D SCREENER

ID NUMBER **AGE** **SEX**

ID NUMBER	AGE
0 0 0 0 0 0 0 0 0	0 0
1 1 1 1 1 1 1 1 1	1 1
2 2 2 2 2 2 2 2 2	2 2
3 3 3 3 3 3 3 3 3	3 3
4 4 4 4 4 4 4 4 4	4 4
5 5 5 5 5 5 5 5 5	5 5
6 6 6 6 6 6 6 6 6	6 6
7 7 7 7 7 7 7 7 7	7 7
8 8 8 8 8 8 8 8 8	8 8
9 9 9 9 9 9 9 9 9	9 9

SEX: ○ Male ○ Female

If female, are you pregnant or breastfeeding?
○ No
○ Yes

How often do you usually eat each of the foods listed below? Remember breakfast, lunch, dinner, snacks, and when eating out.

Please use a pencil.

	HOW OFTEN IN THE PAST YEAR?						HOW MUCH ON THOSE DAYS?		
	Never	2-3 times per month	1-2 times per week	3-4 times per week	5-6 times per week	Every day			
Eggs or breakfast sandwiches with eggs	○	○	○	○	○	○			
Breakfast cereal, like corn flakes	○	○	○	○	○	○			
Oatmeal	○	○	○	○	○	○			
Orange juice	○	○	○	○	○	○	○ 1 glass	○ 2 glasses	○ 3 glasses
Glasses of regular milk, soy milk, chocolate milk or cocoa (Don't count milk on cereal)	○	○	○	○	○	○	○ 1 glass	○ 2 glasses	○ 3 glasses
Drinks like Sego, Slimfast, Slender or Ensure	○	○	○	○	○	○	○ 1 glass	○ 2 glasses	○ 3 glasses
Breakfast bars, granola bars or energy bars like Power Bar, Slimfast Bar	○	○	○	○	○	○	○ 1 bar	○ 2 bars	○ 3 bars
Bread, rolls or English muffins	○	○	○	○	○	○	○ 1 slice	○ 2 slices	○ 3+ slices
Tortillas	○	○	○	○	○	○	○ 1 tortilla	○ 2 tortillas	○ 3+ tortillas
Hamburger or cheeseburger with bun	○	○	○	○	○	○			
Pizza	○	○	○	○	○	○			
Tacos, burritos, enchiladas	○	○	○	○	○	○			
Macaroni & cheese, lasagna or cheese ravioli	○	○	○	○	○	○			
Pinto beans, black beans or chili with beans	○	○	○	○	○	○			
Cheese or cheese spread not counted above	○	○	○	○	○	○			
Yogurt	○	○	○	○	○	○			
Ice cream or frozen yogurt, regular or low-fat	○	○	○	○	○	○			
Cake or doughnuts	○	○	○	○	○	○			
Carbonated soft drinks, like Coke, ginger ale, orange soda or any kind (diet or regular)	○	○	○	○	○	○	○ 1 glass	○ 2 glasses	○ 3 glasses
Tums or Rolaids	○	○	○	○	○	○	○ 1 tablet per day	○ 2 tablets per day	○ 3 tablets per day
Multiple-vitamins, like One-a-Day, or prenatal	○	○	○	○	○	○			
Calcium supplements	○	○	○	○	○	○			

On the days that you take ***calcium supplements*** (Not including Tums/Rolaids) how many milligrams of calcium do you take **in the whole day?** ○ 300mg ○ 500mg ○ 600mg ○ 800mg ○ 1000mg ○ 1200mg ○ 1500mg ○ 1600mg

When you eat ***bread or rolls***, is it usually ○ Calcium-enriched ○ Not calcium-enriched ○ Don't know

When you drink ***orange juice***, is it usually ○ With added calcium ○ Without added calcium ○ Don't know

When you eat ***burgers*** are they usually ○ Hamburgers ○ Cheeseburgers ○ Both equally

When you eat ***cold cereal*** is it usually ○ "Total" brand cereal ○ Some other kind of cereal

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APPENDIX C

HEEL SCAN RESULTS PRINT OUT

HOLOGIC

Date Time

Serial No:

Name: ____________________

Sex: M F

ID#:______________________

Ethnicity:__________________

DOB____/____/___ Age:_____

Foot: L R

QUI/Stiffness:

Est Heel BMD:

T-Score:

*T-score based on US Caucasian female reference data

APPENDIX D

SOCIAL COGNITIVE QUESTIONNAIRE

PERCEPTIONS OF PHYSICAL ACTIVITY QUESTIONNAIRE

We would like to find out about how you perceive physical activity and physical activity opportunities available to you. This questionnaire consists of 72 items. Please provide an answer to every question, and please respond as honestly as possible. There are no right or wrong answers. All responses will be kept confidential.

A. This section of the questionnaire looks at how confident you feel doing exercise. Please indicate your degree of confidence in your ability to perform each activity listed below by placing an "X" on the line for each item.

Placing an **"X"** at the lower end (left) indicates you are *not at all confident.*
Placing an **"X"** at the upper end (right) indicates you are *very confident.*

If it were recommended that do any of the following this week, how confident are you that you could…

Example: *Eat 3 servings of vegetables daily* — *Not at all confident* |______________________________________***X***______________| *Very confident*

1. Begin a new or different exercise program — Not at all confident |____| Very confident

2. Change your exercise habits — Not at all confident |____| Very confident

3. Put forth the effort required to exercise — Not at all confident |____| Very confident

4. Do exercises even if they are difficult — Not at all confident |____| Very confident

5. Maintain a regular exercise program — Not at all confident |____| Very confident

6. Exercise for 30 minutes at a moderate intensity (*i.e., intensity that increases your heart rate and causes you to perspire*)	Not at all confident	|____|	Very confident
7. Do exercises even if they are tiring	Not at all confident	|____|	Very confident
8. Stick to your exercise program	Not at all confident	|____|	Very confident
9. Exercise at least three times per week	Not at all confident	|____|	Very confident
10. Do weight bearing aerobic (i.e., *walking, jogging, or biking)* <u>OR</u> strength training exercises (*i.e., weight lifting with machines or free weights)*	Not at all confident	|____|	Very confident

B. This section looks at how confident you are in your ability to exercise when other things get in the way. Please read the following items and circle the number that best expresses how each item relates to you in your leisure time.

For your ratings, please answer each item using the following 5-point scale:

1	2	3	4	5
not at all confident		moderately confident		completely confident

I feel confident in my ability to exercise even if…

	not at all confident		moderately confident		completely confident
	1	**2**	**3**	**4**	**5**
11. I am under a lot of stress	1	2	3	4	5
12. I am depressed	1	2	3	4	5
13. I am anxious	1	2	3	4	5
14. I feel I don't have the time	1	2	3	4	5
15. I don't feel like it	1	2	3	4	5
16. I am busy	1	2	3	4	5
17. I am alone	1	2	3	4	5
18. I have to exercise alone	1	2	3	4	5

Please answer the following using the following 5-point scale:

1	2	3	4	5
not at all confident		**moderately confident**		**completely confident**

I feel confident in my ability to exercise even if…

	not at all confident 1	2	moderately confident 3	4	completely confident 5
19. My exercise partner decides not to exercise that day	1	2	3	4	5
20. I don't have access to exercise equipment	1	2	3	4	5
21. I am traveling	1	2	3	4	5
22. My gym is closed	1	2	3	4	5
23. My friends don't want me to exercise	1	2	3	4	5
24. My significant other does not want me to exercise	1	2	3	4	5
25. I am spending time with friends or family who do not exercise	1	2	3	4	5
26. It's raining or snowing	1	2	3	4	5
27. It's cold outside	1	2	3	4	5
28. The roads or sidewalks are wet, icy, or snowy	1	2	3	4	5

C. This section lists things people might do or say to someone who is trying to exercise regularly. If you are not trying to exercise, then some of the questions may not apply to you, but please read and give an answer to every question.

Please rate each question *twice*.

Next to FAMILY, rate how often anyone in your family or anyone living in your household has said or done what is described in each item below during the last three months. Please **circle** your response.

Next to FRIENDS, rate how often your friends, acquaintances, or co-workers have said or done what is described in each item below during the last three months. Please **circle** your response.

For your ratings, please use the following scale to rate your responses to each item:

none	**rarely**	**a few times**	**often**	**very often**	**does not apply**
1	**2**	**3**	**4**	**5**	**8**

During the past 3 months my FAMILY (or members of my household) and FRIENDS:

29. Exercised with me

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

30. Offered to exercise with me

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

31. Gave me helpful reminders to exercise (i.e., “Are you going to exercise tonight?”)

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

For your ratings, please use the following

none	rarely	a few times	often	very often	does not apply
1	**2**	**3**	**4**	**5**	**8**

During the past 3 months my FAMILY (or members of my household) and FRIENDS:

32. Gave me encouragement to stick with my exercise program

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

33. Changed their schedule so we could exercise together

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

34. Discussed exercise with me

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

35. Complained about the time I spend exercising

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

For your ratings, please use the following

none	rarely	a few times	often	very often	does not apply
1	**2**	**3**	**4**	**5**	**8**

During the past 3 months my FAMILY (or members of my household) and FRIENDS:

36. Criticized me or made fun of me for exercising

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

37. Gave me rewards for exercising (bought me something or gave me something I like)

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

38. Planned for exercise or recreational outings

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

39. Helped plan activities around my exercise

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

For your ratings, please use the following

none	rarely	a few times	often	very often	does not apply
1	**2**	**3**	**4**	**5**	**8**

During the past 3 months my FAMILY (or members of my household) and FRIENDS:

40. Asked me for ideas on how they can get more exercise

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

41. Talked about how much they like to exercise

FAMILY	1	2	3	4	5	8
FRIENDS	1	2	3	4	5	8

D. This section lists exercise or recreational items commonly found in the home.

Please indicate which items you have in your home, yard, or apartment complex. Please **circle** an answer to each question.

42. Stationary aerobic equipment such as a treadmill, stationary bike, spin bike, or elliptical machine	YES	NO
43. Trampoline for jumping or jogging in place	YES	NO
44. Bicycle	YES	NO
45. Swimming Pool	YES	NO
46. Tennis shoes/running shoes or hiking boots	YES	NO

47. Weight lifting equipment such as free weights, Nautilus®, Universal®, Total Gym®, or Bow Flex® YES NO

48. Toning devices such as resistance bands, medicine balls, stability/ab balls, kettle bells, ab wheel, or Bosu® YES NO

49. Workout videos, DVD's, or Wii Fit®, or other computer-based active play programs YES NO

50. Aerobic step or slide YES NO

51. Roller skates, in-line skates, or ice skates YES NO

52. Sports equipment such as racquets, bats, balls, or clubs YES NO

53. Snow skis, water skis, snowboard, wakeboard, or snow shoes YES NO

54. Canoe, kayak, row boat, or paddle boat YES NO

E. This section lists physical activity or recreational facilities commonly found in neighborhoods.

For each of these places where you can exercise or do recreational activity, please indicate if it is on a **frequently traveled route (e.g. to and from work) or within a 5-minute walk or 10-minute drive from your work or home**. Please **circle** an answer for each item.

55. Aerobic dance studio (Jazzercise®, Zumba®, etc.) YES NO

56. Basketball court YES NO

57. Beach or lake YES NO

58. Bike lane or trails	YES	NO
59. Golf course	YES	NO
60. Health club/gym/YMCA	YES	NO
61. Martial arts studio	YES	NO
62. Playing field (soccer, football, softball, etc.)	YES	NO
63. Public park	YES	NO
64. Public recreation/community center	YES	NO
65. Racquetball court	YES	NO
66. Running track	YES	NO
67. Skating rink	YES	NO
68. Swimming pool	YES	NO
69. Walking/hiking trails	YES	NO
70. Tennis courts	YES	NO
71. Dance studio (ballet, ballroom, Latin, hip hop, etc.)	YES	NO
72. Yoga or Pilates studio	YES	NO

THANK YOU FOR PARTICIPATING!!!

APPENDIX E

MODIFIABLE ACTIVITY QUESTIONNAIRES (MAQ) AND SCORING INSTRUCTIONS

PARTICIPANT ID _____________
DATE______/________/_______

PAST YEAR MODIFIABLE ACTIVITY QUESTIONNAIRE: INTERVIEW

1. Please check the box ☑ of all activities that you have done more than 10 times in the last 12 months:
from ____/_____/_____ to ____/_____/_____.

	Activity	Month												Frequency	Duration
☑		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average # of times per month	Average # of minutes each time
	Aerobic Dance/ Exercise (Zumba, Jazzercise, tae-bo)														
	Badminton														
	Basketball														
	Bicycling (indoor, outdoor)														
	Bowling														
	Canoeing/Rowing/Kayaking														
	Dancing (ballroom, Latin, ballet, line, square)														
	Elliptical														
	Fencing														
	Fishing														
	Gardening or Yardwork														
	Golf														
	Hiking														
	Horseback Riding														
	Hunting														
	Jogging/Running (outdoor, indoor)														
	Jumping rope														
	Martial arts (karate, judo, taekwondoe)														
	Pilates														
	Plyometrics (jumps, bounds, box jumps)														
	Racquetball/Handball														
	Rock Climbing														
	Scuba Diving														
	Skating (roller, ice, in-line)														
	Softball/Baseball														
	Stairmaster/Stairclimber														

	Strength/Weight Training (free weights, machines)														
	Swimming (laps, snorkeling)														
	Tai Chi														
	Tennis														
	Toning (resistance bands, body bars, ab/stability balls)														
	Volleyball														
	Walking for Exercise (outdoor, indoor, treadmill)														
	Water Aerobics														
	Water skiing/Wakeboarding														
	Yoga														
	Other:														

2. Excluding time at work, in general how many HOURS per DAY did you usually spend watching television or working on a computer <u>over the past year</u>? ___________ hours

3. Over the past year, have you spent more than one day confined to a bed or chair as a result of an illness, injury, or or surgery? ☐ YES ☐ NO

   If yes, how many weeks <u>over the past year</u> were you confined to a bed or chair? ____________ weeks

4. <u>Over the past year</u>, did you have difficulty doing any of the following activities?

   a. Getting in or out of bed or a chair? ☐ YES ☐ NO

   b. Walking across a small room without resting ☐ YES ☐ NO

   c. Walking for 10 minutes without resting ☐ YES ☐ NO

5. Did you ever compete in an individual or team sport (not including any time spent in sports performed during physical education classes)? ☐ YES ☐ NO

   If yes, how many years did you participate in competitive sports? _________ years

---

6. Have you had a job for more than one month <u>over the past year</u>, from last ________ to this ________?(enter date range) ☐ YES ☐ NO

7. List all JOBS held over the past 12 months for more than one month. Account for all 12 months of the past year. IF homemaker, student, unemployed, disabled during all or part of the past 12 months, list as such and identified job activities of a normal 8 hour day, 5 days per week.

Job Name	Job Code	Walk or bicycle to/from work	Average Job Schedule			Hrs. spent Sitting At Work (out of work hrs/day reported)	Check the category that best describes job activities when not sitting		
		Min/ day	Mos/ Yr	Days/ Wk	Hrs/ Day	Hrs Spent Sitting	A	B	C

Category A (includes all sitting activities)	**Category B** (includes most indoor activities)	**Category C** (heavy industrial work, outdoor construction, farming, landscaping)
Sitting	Carrying light loads	Carrying moderate to heavy loads
Standing still w/o heavy lifting	Continuous walking	Heavy construction (roads, homes, commercial)
Light cleaning	Heavy cleaning	Farming
Driving a bus, tractor, police car, taxi	Gardening	Digging, shoveling
General office work	Painting/Plastering	Chopping or sawing work
Occasional short distance walking	Plumbing/Welding/Electrical	Landscape work
Teaching (K-12, college)	Factory/line work	Heavy hauling of wood, materials, products

JOB CODES	
Not employed outside the home:	Employed (or volunteer):
1. Student	6. Armed Services
2. Home Maker	7. Office Worker
3. Retired	8. Non-Office Worker
4. Disabled	
5. Unemployed	

PAST YEAR MAQ SCORING

For each past year activity, the months per year, frequency per month, and minutes per session will be identified. For each activity the following steps will be taken to code the data:

1. Average weekly leisure activity (hr/wk) performed over the past year will be calculated for each activity by the formula [(mo/yr) x (freq/mo) x (min/session) ÷ 60 min/hr] ÷ 52 wk/yr = leisure hr/wk (Kriska, 1997).

2. Average weekly occupational and transport activity (h/wk) performed over the past year will then be calculated for each job by the formula [(mo/yr) x (wk/mo) x (days/wk) x (hr/day work – hr/day sitting) + (hr/day transport)] ÷ 52 wk/yr = occupational and transport hr/wk (Kriska, 1997).

3. Hours per week multiplied by the corresponding MET value for each activity to obtain activity MET-hrs/wk (Ainsworth, 2000). Only MET values ≥ 3.0 METS will be used. MET-hrs per week for moderate to vigorous activities (≥ 3.0 METS) across each domain will be summed to obtain average MET-hrs/week spent in moderate-vigorous intensity activities over the past year (YRMV-MET-hrs/wk).

PARTICIPANT ID ______________
DATE______/________/_______

PAST WEEK MODIFIABLE ACTIVITY QUESTIONNAIRE

1. Please check the box of all activities that you have done during the past **7** days. For each activity that was checked ☑, write down the total # of minutes that you spent doing the activity per day.

	Activity	Total Minutes per Day						
☑	from ________ to _________ day/date day/date	SUN	MON	TUE	WED	THUR	FRI	SAT
	Aerobic Dance/Aerobic Group Exercise (step, Zumba cardio-kickboxing, hip hop, Jazzercise, etc.)							
	Badminton							
	Basketball							
	Bicycling (stationary, indoor, spinning, outdoor)							
	Bowling							
	Canoeing/Rowing/Kayaking							
	Dancing (ballroom, Latin, ballet, line, square)							
	Elliptical							
	Fencing							
	Fishing							
	Gardening or Yardwork							
	Golf							
	Hiking							
	Horseback Riding							
	Hunting							
	Jogging/Running (outdoor, indoor)							
	Jumping rope							
	Martial arts (karate, judo, taekwondoe)							
	Pilates							
	Plyometrics (jumps, bounds, box jumps)							
	Racquetball/Handball							
	Rock Climbing							
	Scuba Diving							
	Skating (roller, ice, in line)							
	Softball/Baseball							
	Stairmaster/Stairclimber							
	Strength training/Weight Training (free weights, machines, total gym)							
	Stairmaster/Stairclimber							
	Swimming (laps, snorkeling)							
	Tai Chi							
	Tennis							
	Toning (resistance bands, body bars, ab/stability balls)							
	Volleyball							
	Walking for Exercise (outdoor, indoor, treadmill)							
	Water Aerobics							
	Water skiing or Wakeboarding							
	Yoga							

	Other:							
	I did NONE of the listed activities over the past 7 days							

2. Was this week reflective of your usual activity levels? ☐YES ☐ NO

3. Excluding time at work, in general how many HOURS per DAY did you usually spend watching television or working on a computer <u>over the past week</u>? ___________ hours

4. <u>Over the past week</u>, have you spent more than one day confined to a bed or chair as a result of an illness, injury, or surgery? ☐YES ☐ NO

   If yes, how many days over the past week were you confined to a bed or chair? ____________ days

5. <u>Over the past week</u> did you have difficulty doing any of the following activities?

   a. Getting in or out of bed or a chair? ☐YES ☐ NO

   b. Walking across a small room without resting ☐YES ☐ NO

   c. Walking for 10 minutes without resting ☐YES ☐ NO

6. Did you have a job that you worked over the past week? ☐ YES ☐ NO

7. List all JOBS held over the **past week**. If homemaker, student, unemployed, or disabled, list job activities of a normal 8 hour day over the past week.

Job Name	Job Code	Walk or Bicycle to/from work Min/Day	Average Job Schedule		Hrs Spent Sitting at Work	Check the category that best described your work when you were not sitting		
			Days/Wk	Hrs/Day	Hrs Sitting	A	B	C

Category A (includes all sitting activities)	**Category B** (includes most indoor activities)	**Category C** (heavy industrial work, outdoor construction, farming, landscaping)
Sitting	Carrying light loads	Carrying moderate to heavy loads
Standing still w/o heavy lifting	Continuous walking	Heavy construction (roads, homes, commercial)
Light cleaning	Heavy cleaning	Farming
Driving a bus, tractor, police car, taxi	Gardening	Digging, shoveling
General office work	Painting/Plastering	Chopping or sawing work
Occasional short distance walking	Plumbing/Welding/Electrical	Landscape work
Teaching (K-12, college)	Factory/line work	Heavy hauling of wood, materials, products

JOB CODES	
Not employed outside the home:	Employed (or volunteer):
1. Student	6. Armed Services
2. Home Maker	7. Office Worker
3. Retired	8. Non-Office Worker
4. Disabled	
5. Unemployed	

For interviewer only:
Check the box that best reflects the month that the physical activity data were collected

☐ June-Aug ☐ Sept-Nov ☐ Dec-Feb ☐ March-May

PAST WEEK MAQ SCORING

For each past week activity, the frequency (days/wk) and minutes per day (min/day) will be identified. For each activity the following steps will be taken to code the data:

1. Past week leisure activity (hr/wk) will be calculated for each activity by the formula [(days/wk) x (min/day) ÷ 60 min/hr] = leisure hr/wk (Kriska, 1997).

2. Past week minutes per day reported for transport will be converted to hours per day (hr/day) by the researcher with the formula [(min/day transport) ÷ 60min/hr = hr/d transport] (Kriska & Bennet, 1992; Kriska et al., 1990).

3. Past week (h/wk) occupational and transport activity will be calculated by the formula [(d/wk) x (hr/day work – hr/day sitting) + (hr/day transport)] = occupational and transport hr/wk (Kriska, 1997).

4. Hr/wk for leisure and occupational/transport activities will be multiplied by the corresponding MET value for that activity (Ainsworth, 2000).). Only MET values ≥ 3.0 METS will be used.

5. Values for leisure activities will be summed and values for occupational activity will be summed to obtain past week leisure MET-hrs/week (LMV-MET-hrs/wk) and occupation/ transport MET-hrs/week (OMV-MET-hrs/wk) spent in moderate-vigorous intensity activities (≥ 3.0 METS).

APPENDIX F

INFORMED CONSENT DOCUMENT

INFORMED CONSENT DOCUMENT

Project Title: **The influence of social cognitive factors on MVPA in Peri- and Postmenopausal Women**

Principal Investigator: Heather Medema-Johnson, M.S.

Research Team Contact: Heather Medema-Johnson 309-781-1170
Kathleen F. Janz 319-335-9345

This consent form describes the research study in order to help you decide if you want to participate. This form provides important information about what you will be asked to do during the study, about the risks and benefits of the study, and about your rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- You should discuss your participation with anyone you choose such as family or friends.
- Do not agree to participate in this study unless the research team has answered your questions and you decide that you want to be part of this study.

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research study. We are inviting you to participate in this research study because you are a healthy, peri- or postmenopausal woman between the ages of 45 to 65.

Osteoporosis is a debilitating disease that is characterized by low bone mass and structural breakdown of the skeleton, which makes bones subject to fracture. Osteoporosis affects 44 million people, and 68% of those are women (USDHHS, 2007). One way that osteoporosis may be prevented is through moderate to vigorous, weight-bearing physical activity. This is especially important for populations at greatest risk for the disease, including peri- and postmenopausal women. Despite the benefits of physical activity, according to the Centers for Disease Control (2007), only 47% of all women participate in activity according to guidelines. Because physical *in*activity can negatively impact bone health, understanding factors that influence physical activity behavior is critical for osteoporosis prevention. Therefore, the purpose of this research study is to understand and describe behavioral factors that influence moderate to vigorous physical activity among peri- and postmenopausal women. Additionally, this study will examine the association between moderate to vigorous physical activity and the estimated bone density of these women. This information may help researchers, practitioners, and public health officials design and implement interventions that aim to prevent osteoporosis in at-risk populations.

HOW MANY PEOPLE WILL PARTICIPATE?

Approximately 90 women from eastern Iowa and western Illinois will take part in this study being conducted through the University of Iowa.

HOW LONG WILL I BE IN THIS STUDY?

If you agree to take part in this study, your involvement will last for 7 to 8 days.

- This will involve 2 meetings, including:
  - One face-to-face meeting, which will take 2 hours
  - One follow-up phone conversation, which will take 20 minutes
  - The phone conversation will take place one week after the first face-to-face meeting

WHAT WILL HAPPEN DURING THIS STUDY?

<u>During the First Face-to-Face Meeting</u>: total time 2 hours

Questionnaires/Measures

- Your body weight will be measured with a standard floor scale.
- You will be asked to answer a short questionnaire about your demographic and health information. This will including height, age, race, marital status, number of children, annual household income, highest level of education completed, smoking status, average weekly alcohol consumption, menopausal status, and specific medications and conditions that may affect bone health.
- You will be asked to complete a short survey pertaining to your calcium and vitamin D intake.
- You will also be asked to complete a 71-item questionnaire, providing a rating to questions about your physical activity perceptions and opportunities for physical activity.
- You will be asked to complete a short, 30-minute physical activity interview about your high-school exercise/sport activity and past year physical activity.
- You many skip any questions you do not feel comfortable answering.

Heel Scan

- You will be asked to undergo a brief heel scan to *estimate* your bone density through quantitative ultrasound (QUS)

  -- DXA bone density scans are considered the most effective, valid technique currently available for measurement of bone density; however, DXA scans are expensive, time consuming, and are not available to everyone. Therefore, we will be using a different type of scan that provides an estimate of bone density, called a Quantitative Ultrasound (QUS). This instrument measures stiffness of the heel bone (calcaneus), is less expensive, more readily available, and provides a reliable estimate of bone density.

- For this scan, you will be asked to sit in a chair, your heel will be cleaned with alcohol-free baby wipes, and you will be asked to and place your heel into the heel well of the scanner.
- Your leg will be secured with a low leg brace that is secured to your leg with Velcro straps, similar to a tall ankle brace.
- You will be asked to sit still and rubberized measurement devices called transducers, coated with hypoallergenic gel, will press firmly against each side of your heel. The pressure applied by the transducers should not cause any discomfort.
- This test will be run one time, and the setup and measurement process will take less than one minute.
- The measurement provided will be used to estimate your bone density, but this is not an actual measure of your bone density. The bone measures for this study are not being used to evaluate your health. The information obtained for this study is only for specific research purposes and are not being used to find medical abnormalities.

Physical Activity Monitor

- You will be asked to wear a sealed activity monitor for the next 7 days. This monitor (pedometer) is 2 ½" x 1/2" x 1" in size, and it has a clip on the back, similar to a cell-phone clip. This monitor will be placed on the waistband or belt of your clothing near your right hip, and secured to your clothing with a security strap that has an alligator-style clip attached to it. This monitor will measure how many steps you take each day and how many minutes you spend doing moderate to intense activity.
- Along with the monitor, you will be given a monitor on/off log, and you will be asked to write the times you put the monitor on and take the monitor off each day.

Time and Location

- The first meeting will last 2 hours, and it will take place either in your home or at my office at the Kinesiology and Athletics Center at St. Ambrose University, Davenport, IA. This location will be based on your preference. The time of day will be agreed upon by you and the investigator.

<u>During the Follow-Up Phone Call One Week Later</u>: total time 20 minutes

- One week following the first face-to-face meeting, you will receive a follow-up phone call.
- You will be asked to break the seal on the activity monitor and read (out loud) your physical activity information, including steps and activity minutes for each day you wore the monitor. The investigator will record this information.
- You will be asked to complete a short, 15-minute physical activity interview

about your physical activity over the past week. You may skip any questions you do not feel comfortable answering.
- You will be asked to mail the monitor and monitor on/off log in a postage paid return envelope that will be given to you.
- You will be verbally given the results of your heel scan, which will also be mailed to you.

WHAT ARE THE RISKS OF THIS STUDY?

You may experience one or more of the risks indicated below from being in this study. In addition to these, there may be other unknown risks, or risks that we did not anticipate, associated with being in this study.

Questionnaires
- During the first meeting, you will fill out a series of questionnaires relating to your demographic, health, and physical activity information. You will be asked to answer these questions because they are relevant to your bone health. While the risks are minimal, there is always the chance that some questions could make you feel emotionally uncomfortable. However, only the study investigator will have access to this information. Remember you may skip any questions you do not feel comfortable answering.

Heel Scan
- For the heel scan, your heel will be cleaned with alcohol-free, lint-free wipes (baby wipes). Additionally, manufacturer provided hypoallergenic gel will be used. While these rarely cause an allergic response, unforeseen reactions could occur. If this happens you will be encouraged to clean the area with soap and warm water and to contact your physician.

- Past medical information and current experience suggests no known risks from a heel ultrasound. There is no x-ray exposure, the footrest is not uncomfortable, and the sound waves used cannot be heard or felt. The actual setup and QUS scan time quite short (less than one minute).

Activity Monitor
- There should be no risk or discomfort to you from wearing the activity monitor. You will also be provided with instructions to ensure the most comfortable and accurate positioning of the monitor.

Although risks of these procedures are minimal, if you should experience discomfort, you are encouraged to contact a local health provider for treatment

WHAT ARE THE BENEFITS OF THIS STUDY?

You will receive your own physical activity information that was collected with the physical activity monitor. You will also receive the results of your estimated bone density, as measured through the heel scan. We also hope that, in the future, other people might benefit from this study because your participation will provide information on perceptions of and opportunities for physical activity, physical activity behaviors, and bone health that may help others.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

There is no financial cost to you for participation in this study. If you choose to conduct the first meeting at the investigator's office, you may incur travel expenses (i.e., gas and mileage). There is no cost for parking at the investigator's office. However, you have the option to have the investigator come to your home.

WILL I BE PAID FOR PARTICIPATING?

You will not receive monetary payment for participating in this study. However, following completion of this study, you will verbally receive the results of your estimated bone density scan as a token of appreciation for your participation. You will also receive a mailed copy of these results with information on how to interpret this information. These tests can cost between $35.00 and $115.00 when conducted in other settings.

WHO IS FUNDING THIS STUDY?

This study is not being funded.

WHAT ABOUT CONFIDENTIALITY?

We will keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people such as those indicated below may become aware of your participation in this study and may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

- federal government regulatory agencies,
- auditing departments of the University of Iowa, and
- the University of Iowa Institutional Review Board (a committee that reviews and approves research studies)

To help protect your confidentiality, we will assign a personal identifier in the form of a 3-digit number. The personal information that links you to the number is kept in a secure database to which only authorized personnel have access. All questionnaires and other information are secured in file cabinets in locked rooms. All personal identifiers are removed from correspondence and only the number is used for identification purposes. If we write a report or article about this study or share the study data set with others, we will do so in such a way that you cannot be directly identified. A copy of this Informed Consent Document will be placed in a locked filing cabinet.

IS BEING IN THIS STUDY VOLUNTARY?

Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won't be penalized or lose any benefits for which you otherwise qualify.

WHAT IF I DECIDE TO DROP OUT OF THE STUDY EARLY?

If you decide to leave the study early and we have already given you the activity monitor, we will ask you to return the activity monitor to us in a postage-paid envelope. If your heel scan measures were obtained prior to your decision to leave the study, you will still be given the results of your heel scan if you request that information.

WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. If you have any questions about the research study itself, please contact: Heather Medema-Johnson at 309-781-1170. If you experience a research-related injury, please contact: Heather Medema-Johnson at 309-781-1170 or Dr. Kathleen Janz at 319-335-9345.

If you have questions, concerns, or complaints about your rights as a research subject or about research related injury, please contact the Human Subjects Office, 340 College of Medicine Administration Building, The University of Iowa, Iowa City, Iowa, 52242, (319) 335-6564, or e-mail irb@uiowa.edu. General information about being a research subject can be found by clicking "Info for Public" on the Human Subjects Office web site, http://research.uiowa.edu/hso. To offer input about your experiences as a research subject or to speak to someone other than the research staff, call the Human Subjects Office at the number above.

This Informed Consent Document is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You are not waiving any legal rights by signing this Informed Consent Document. Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subject's Name (printed):____

Do not sign this form if today's date is on or after $STAMP_EXP_DT .

____________________________________ _________________________
(Signature of Subject) (Date)

Statement of Person Who Obtained Consent

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative. It is my opinion that the subject understands the risks, benefits, and procedures involved with participation in this research study.

____________________________________ _________________________

(Signature of Person who Obtained Consent) (Date)

APPENDIX G

PARTICIPANT ELIGIBILITY CHECKLIST

EXCLUSION CRITERIA CHECKLIST: *FOR RESEARCHER USE ONLY*

1) Name____

2) Age_______________ Between age 45 and 65 at the time of study: Yes No

3) Have you started seeing alterations in your menstrual cycle or have your menstrual periods stopped?

Yes No

4) Are you able to perform regular activity and activities of daily living without the use of an external assistive device such as a cane or walker?

Yes No

---

5) Have you ever been diagnosed with a fragility fracture or osteoporosis?

Yes No

6) Are you currently taking or have you ever taken either of the following medications?

Anticonvulsants	Yes	No
Glucocorticoids	Yes	No

7) Have you ever been <u>clinically diagnosed</u> with an eating disorder such as Anorexia Nervosa or Bulimia?

Yes No

8) Have you ever been diagnosed with diabetic neuropathy?

Yes No

Exclusion Criteria:

Any "NO" response to questions 2-4 ____

Any "YES" response to items 5-8 ____

______Must EXCLUDE from the study _______May INCLUDE in the study

APPENDIX H

ACTIVITY MONITOR INSTRUCTIONS AND LOG

DAILY ON/OFF LOG BOOK FOR THE ACTIVITY MONITOR

Instructions: Please record when you put on and took off your activity monitor. This information is vital to analyzing the information that will be collected from the activity monitoring you are wearing at your right hip. It is extremely important that you wear the monitor all day, except for when sleeping or showering.

Initials: ____________ Subject Number ___________________

Date	**Time Awoke**	**Time Monitor On**	**Time Monitor Off and On (if took off during the day)**	**Time Monitor Off at end of day**	**Time Asleep**	**Notes**
EXAMPLE						
1/30/07	8 AM	8 AM	11 AM-11:45 For shower	9:45 PM	9:45 PM	No problems
YOUR DAILY MONITOR ON/OFF TIMES						

INSTRUCTIONS FOR ACTIVITY MONITOR USE

As part of this research study, you will be asked to wear an activity monitor for 7 days. This device will record the number of steps you take and time spent at or above moderate activity intensity. At the completion of the study this information will be provided to you along with activity recommendations.

The activity monitor should be placed at your right hip, on the waistband of your pants or on your belt. If you are wearing a dress without a waistband or belt, please clip the monitor onto your underwear. Please make sure the New Lifestyles NL-1000 decal is facing out and the clip is against your body. Place the monitor between your hip and belly button, so it is in line with the midline of your thigh.

Please do not open the sealed monitor. Whenever you are wearing the monitor, the safety strap should be clipped to your waistband, a belt loop, pocket, or bunched up material from your clothing. If you are wearing a dress without a waistband or belt, please attach the safety strap to your underwear. See the below picture for proper placement.

You should wear the activity monitor during all waking hours. Put the activity monitor on when you first get up in the morning and wear until you go to bed at night. Take the monitor off during bathing, showering, or during swimming and then put the monitor back on.

Throughout the day, check to make sure the activity monitor is still placed squarely on your waistband or belt.

Please complete the attached monitor log when you put the monitor on and take it off each day. This is done so we ensure the activity monitor is working correctly. It also gives up a way to make sure that the data on the activity monitor truly reflects what you did during a day.

If you have any questions or concerns about the activity monitor, please contact **Heather Medema-Johnson at (309) 781-1170.** Thank you very much!

APPENDIX I

ACTIVITY MONITOR AND HEEL SCAN FEEDBACK LETTER

NAME
ADDRESS

DATE

Dear _________________,

Thank you for your recent participation in the women's physical activity research study I am conducting for my doctoral work! As I am sure you remember, for this study you wore an activity monitor for one week in the summer. This was done to measure how active you were. You also completed a series of questionnaires and underwent a heel scan to estimate your bone density. I want to provide you with your activity monitor and heel scan results, as well as classification/reference data for these measurements so you can interpret your results.

Activity monitor:

Number of days you wore the monitor for at least 8 hours/day =

Your average number of steps per day =

Recommendation: Here are some general classifications of activity status associated with steps per day:

Classification	**Steps/Day**
Sedentary	< 5000
Low Active	5000 – 7499
Somewhat Active	7500 – 9999
Active	10,000 – 12,499

Your average number of moderate to vigorous activity minutes per week =

Recommendation: According to the Surgeon General, you should obtain 150 min/week of moderate to vigorous physical activity.

<u>Heel scan:</u>

The ultrasound test provided an *estimate* of your bone mineral density. The results of your test are reported as a Z-score, which indicated standard deviations. This tells us how far above or below your score is from the average score for women your age.

For example, a Z-score of -1.0 means that your bone density is 1 standard deviation below the average for women your age, where a Z-score of +2.0 means that your bone density is 2 standard deviations above the average for women your age.

Your *estimated* Z-score:

Recommended interpretation:

Z-score	**Reference**
0.0 and above	Your estimated BMD is equal to or greater than the average value for Caucasian females of the same age.
Between -2.0 and 0.0	Your estimated BMD is slightly below the average value for Caucasian females of the same age
-2.0 or below	Your estimated BMD is below the average value for Caucasian females of the same age.

The heel ultrasound is a screening tool and the results it provides are an estimate. It CANNOT be used to make the diagnosis of osteoporosis or low bone density. If your Z-score is substantially lower than the average bone density for women your age, you should discuss this finding with your doctor.

Thank you again for your participation in the study. If you have any questions or concerns, please feel free to contact me at 309-781-1170.

Sincerely,

Heather Medema-Johnson, M.S.

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