

BODY COMPOSITION AND PHYSICAL FUNCTION: PHYSIOLOGICAL  
OUTCOMES AND PERCEPTIONS ACROSS THE FUNCTIONAL SPECTRUM IN  
OLDER WOMEN

by

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ABSTRACT

In older women, physical function (PF) is impacted by physical activity (PA), adiposity (%Fat), muscle power, and muscle quality (MQ). The aim of this study was to assess the influences of PA, %Fat, leg power, MQ [lower body power (watts) / lower body lean mass (kg)], on perceived and performance-based PF in older women varying in functional status. Women (n = 97; age = 73.8 ± 5.6 years) were assessed for habitual PA via the CHAMPS questionnaire, body composition via DXA, and leg power via the Nottingham power rig. Lower extremity physical function (LEPF) was evaluated using Physical Performance Test (PPT), 30 second chair rise (CHR), 8 foot up and go (UpGo), and 6 minute walk test (6MWT). Perceived PF was determined using the SF-36 Physical Function scale.

PA (total caloric expenditure per week) was not related to MQ or %Fat. MQ and %Fat were significantly related to LEPF [PPT, UpGo, CHR;  $r = 0.43$  to  $-0.48$  and  $0.35$  to  $-0.39$ , respectively (all  $p < 0.05$ )]. Tertiled by MQ, MQ was associated with PPT scores in a sequential manner such that greater MQ was associated with greater PPT scores;

however, %Fat tertiles were not related to PPT ( $p > 0.05$ ). Perceived PF and performance-based PF (PPT, UpGo, CHR, and 6MWT) were related ( $r$  range -0.41 to 0.52, all  $p < 0.01$ ). Perceived PF was also associated with %Fat, MQ, and PA ( $r = -0.31, 0.26, 0.28$ , respectively, all  $p < 0.05$ ). Regression analyses revealed that age, medical conditions, PA, %Fat, and MQ independently contributed to perceived PF, explaining 38% of the total variance; however, MQ and PA (moderate MET-Hours) were the only significant independent predictors of performance-based PF explaining 31% of the variance.

The findings suggest that MQ and %Fat are associated with LEPF in older women. Perceived PF is associated with performance-based PF, and physiological and behavioral variables, including %Fat, MQ, and PA, may influence perceptions of PF in older women. Future research should utilize an approach which integrates psycho-social, muscle capacity and behavioral outcomes to develop the most effective strategies to enhance PF in older women.

**INDEX WORDS:** Physical function, body composition, older women, muscle quality

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*Jeremiah 29:11*

*“For I know the plans I have for you,” declares the LORD, “plans to prosper you and not to harm you, plans to give you hope and a future.”*

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# CHAPTER 1

## INTRODUCTION

### 1.1 Significance

The older adult population, individuals over the age of 65, is increasing at an unprecedented rate, and it is expected that by the year 2050, one in five individuals will be classified as an older adult (1). Moreover, in the United States, the average life expectancy is also predicted to increase by approximately seven years from 76.0 to 82.6 years by 2050 (2). With increasing age, individuals are more likely to experience declines in physical function and mobility, and subsequently increases in risk for physical disability and loss of independence. The economic impact of an aging population with increased disability is of major concern as older adults utilize the great majority of our country's health care services (3).

Major factors contributing to physical functional decrements with age include changes in habitual physical activity which impact alterations in body composition and subsequently capacity measures, such as muscular strength, muscular power, and muscle quality. Despite a plethora of research findings that support the concept that maintaining physical activity preserves physical functioning in older age, the majority of older adults are relatively sedentary. Estimates indicate that less than 18% of older adults engage in any leisure time physical activity (4).

Changes in body composition, specifically an increase in adiposity and decrease in lean mass, often accompany the aging process and negatively impact physical function.

Obesity is a leading cause of disability among older adults (5, 6). Additionally, inadequate lean mass impacts physical functioning as it is associated with declines in muscular strength, muscular endurance, and muscular power (7, 8). Alterations in body composition further exacerbate and contribute to declines in capacity measures. Research indicates that the average loss of age-related strength ranges from 20 to 40% (9-13) and that muscular power declines even more quickly, at a rate approximately 10% faster than that of muscle strength (14). Muscle quality, commonly expressed as muscle strength per kilogram of body weight or lean mass (15, 16), also declines with age and has been found to be associated with physical function in older adults (10, 17, 18). A non-physiological factor influencing physical function in older adults is the perception of physical function, meaning how one views his/her ability to complete a specific functional task, such as climbing stairs. Although the relationship between perception of physical function and performance-based physical function in older adults has been studied extensively, findings indicate only a moderate association between the measures (19, 20).

A current area of interest regarding older adults is determining which components of body composition and/or capacity measures most strongly relate to and predict physical function. Despite much research, findings remain unclear; although, it appears that muscle power is the strongest predictor of physical function in mobility-limited older adults (21) and adiposity is the strongest predictor of physical function in high functioning, community-dwelling older adults (22-24). Furthermore, psycho-social factors, specifically perception of physical function, has also been found to be related to performance-based physical function, yet the potential contribution of physiological and behavioral variables underlying this relationship remain inadequately explored.

In this context, the primary objective of the proposed research was to evaluate the associations among physical activity, body composition (adiposity), muscle quality, and perceptions of physical function on performance-based physical function in older women. To achieve this objective, older women (n = 99, 65-94 years), varying in functional ability, were evaluated for physical activity, body composition, muscle power, and performance-based and perceived physical function. Though 99 older women completed the testing battery, two were excluded from data analyses as they were statistical outliers in two of the three functional tasks (PPT and UpGo). Both participants were extremely low functioning, approximately four standard deviations below the group means on each of the previously mentioned tasks. The specific aims of this research are as follows:

## **1.2 Specific Aims**

*Specific Aim 1:* To explore how muscle quality, defined using a novel expression (leg power per unit of lower body lean mass), and adiposity differentially influence lower extremity physical function in older women across levels of physical functionality. It was hypothesized that 1) both muscle quality and adiposity would significantly impact lower extremity physical function across all levels of functionality in older women, and 2) both muscle quality and adiposity would exert a dose-response relationship with lower extremity physical function in older women across the functional spectrum, with the highest functioning women having the highest muscle quality and lowest adiposity.

*Specific Aim2:* To determine the relationship among physiological (adiposity, muscle quality) and behavioral (physical activity) variables and perceived physical function in

older women varying in functional status. It was hypothesized that 1) moderate correlations would exist between physical activity, adiposity, and muscle quality and perceived physical function, and 2) physical activity, adiposity, and muscle quality would exert a dose-response relationship on perceived physical function, with women reporting the highest perception of physical function reporting the greatest amounts of physical activity, having the lowest adiposity and highest muscle quality.

*Secondary Aim:* To determine the independent contribution of physical activity, adiposity, and muscle quality to both perceived and performance-based physical function in older women. It was hypothesized that physical activity, adiposity, and muscle quality would independently contribute to both perceived and performance-based physical function in older women.

### **1.3 Public Health Significance**

A more clear understanding of both physiological and behavioral influences on perceived and performance-based physical function in older women necessitates an interdisciplinary collaboration. An awareness of impact of the expanding older adult population, obesity epidemic, and increased physical disability make this research agenda of utmost public health importance.

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## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Public Health Significance of Aging and Functional Limitations**

The number of individuals over the age of 65 is rapidly increasing across the world as well as in the United States. It is estimated that by the year 2050, there will be 88.5 million older adults in the U.S., meaning that one in five individuals will be over the age of 65 (1). Furthermore, during this same time period, life expectancy in the United States is projected to increase from 76.0 years to 82.6 years (2). Comparing across sexes, older women continue to outnumber and outlive older men.

It is well established that with increasing age, individuals are more likely to experience functional declines, mobility limitations, and physical disability. Therefore, with a large majority of “baby boomers” (individuals born between 1946 and 1964) reaching old age in combination with advanced life expectancy, the number of individuals with physical limitations will reach unprecedented levels. According to the CDC, physical limitations can be defined as difficulty performing one of any of the following activities: walking a quarter mile; walking up 10 steps without resting; standing or being on your feet for about two hours; sitting for about two hours; stooping, bending or kneeling; reaching up over your head; using your fingers to grasp or handle small objects; lifting or carrying something as heavy as 10 pounds (3). Current estimates indicate that 23% of individuals 60 to 69 years of age report one or more physical

limitations and that the presence of physical limitations increases with age (3).

Additionally, across all age groups, women are more likely than men to have one or more physical limitations (3). For these reasons, it becomes increasingly important to understand the health challenges of the older adult population, in particular functional limitations, as they contribute to increased hospitalizations, falls, and mortality.

The increased number of older adults in combination with disability is of great concern from a public health perspective. In addition to physical disability and functional declines, older adults may also experience a decreased health-related quality of life. A recently published article cited age, medical care costs, leisure-time physical activity, and smoking as factors that were strongly associated with both physical and mental health in older adults (4). Furthermore, it was estimated that approximately 27%, or \$400 billion, of all U.S. adult health care expenditures in 2006 were due to disability, inclusive of physical, mental, or emotional types (5). A major concern for many older adults is the risk of a fall. Older adults are at greater risk of falls due to a number of contributing factors, including declines in muscular strength and power, poor balance, and slowed reaction times. Approximately one in three older adults falls each year, and it is estimated that the cost of falls among the older adult population will rise to approximately \$54.9 billion by the year 2020 (6). In conclusion, an aging population with increased physical disabilities and decreased health-related quality of life is expected to have strong economic and public health implications in the United States.

## **2.2 Development of Conceptual Model**

A large body of literature supports the interrelationships among various factors that contribute to physical function in older adults (7). Such factors include physical activity, body composition (fat mass and lean mass), capacity measures (leg strength and leg power), and muscle quality, an assessment that combines a measure of body composition and a capacity measure. Furthermore, it is well documented that psychological factors, such as cognition, self-efficacy, and mood, directly impact older adult's physical activity. For example, studies report a direct, positive relationship between self-efficacy and physical activity in older adults (8, 9). Psychological variables can also influence body composition and capacity measures indirectly via physical activity (e.g. older adults who exhibit preserved cognition tend to engage in greater amounts of physical activity and subsequently tend to have favorable body composition and have higher performance on capacity measures) (10, 11). One important psychological factor found to impact physical activity and correlate with performance-based physical function is perceived physical function; however, this area warrants further attention as the literature suggests that only a moderate correlation is present, despite the fact that these two measures are commonly used as surrogate measures of each other. The conceptual model depicted in Figure 1 will be used as a framework to explore factors which influence performance-based physical function in older adults. Specific areas of exploration include the relationships between age and a) physical activity changes (2.3), b) body composition changes (2.4), c) capacity measure changes (2.5), and d) functional changes (2.6). The relation between perceived and performance-based physical function in older adults will also be addressed (2.7).

### **2.3 Physical Activity Changes with Age**

The maintenance of adequate levels of physical activity to preserve physical function and prevent or delay disability during the aging process is well supported in the literature. Older adults who engage in greater amounts of physical activity have a more favorable body composition (12) and greater muscular strength (13). However, it is also well documented that the amount of physical activity declines with age (14-16). Declines in physical activity impact body composition and capacity measures and are associated with decrements in muscle size, muscle strength, and muscle quality. These changes contribute to decrements in physical function and increased disability. More specifically, research indicates that older adults tend to engage in fewer high intensity activities as they age, and there is an increase in sedentary behavior (17). This trend is specifically evident among older women (17).

### **2.4 Body Composition Changes with Age**

The aging process is accompanied by changes in body composition, specifically an increase in adiposity and a decrease in lean mass. Increases in fat mass can directly and indirectly impact physical function. Adiposity is associated with an increased risk for chronic diseases, such as cardiovascular disease and diabetes, which indirectly contribute to functional declines. Furthermore, it is well documented that excess amounts of body fat directly contribute to functional declines by reducing lower extremity physical function and mobility (18, 19). Notably, it has also been reported that obesity is the leading cause of disability among older adults (19, 20). Declines in lean mass directly impact physical function in older adults and are associated with reductions in

muscular strength, muscular endurance, and muscular power, which often result in functional declines (18, 21).

Although both increases in adiposity and declines in lean mass independently contribute to functional declines, these changes in combination further exacerbate the disability process. Individuals at greatest risk for functional declines and subsequent disability are those with an excessive amount of body fat and inadequate lean mass, a body composition disorder termed sarcopenic obesity. Unfortunately, this somatotype represents a growing proportion of the older adult population (18, 20-23).

## **2.5 Capacity Measure Changes with Age**

Aging literature suggests a myriad of factors contributing to declines in capacity measures that accompany the aging process. While a number of these factors can be related to changes in habitual physical activity, other changes within the musculoskeletal system occur during the aging process that impact physical function. Such alterations include significant declines in neuromuscular function and performance (24-26), loss of skeletal muscle mass, and declines in muscular strength and muscular power.

Sarcopenia, literally meaning ‘poverty of flesh’, is an age-associated loss of skeletal muscle mass (27). The definition of sarcopenia is also used to refer to loss of muscle mass, muscle strength, muscle contractile quality and functional decline (28). The underlying mechanisms contributing to sarcopenia are multifactorial and include various factors, such as altered endocrine function, increased inflammation, mitochondrial dysfunction, inadequate nutrition, and cellular apoptosis (29). Despite a specified

mechanism, the loss of lean mass that generally occurs with aging contributes to declines in muscular strength and muscular power.

Recent evidence suggests that merely assessing body composition or cross-sectional area of the muscle may be an inadequate measure to ascertain information regarding physical function in older adults. Indeed, several studies have found a disassociation between loss of muscle mass and loss of muscle strength (30-32). For example, in a five year longitudinal study by Delmonico et al., there was a higher rate of strength loss as compared to loss of muscle size. Older women in the study (average age of 73.2 years at baseline) experienced a 13.4% loss in muscle strength as compared to a 3.2% loss in muscle size over the five year study (33). Physical function capacity measures more appropriately capture an individual's level of functionality as the assessments incorporate the utilization of available lean mass (34). Such measures include tests of muscle strength, muscle power, and muscle quality.

#### *Muscle Strength and Muscle Power*

Comparing across age groups, a number of studies report that individuals in the oldest age groups have lower muscle strength, muscle power, and muscle quality as compared to younger counterparts (30, 35). Specific to muscle strength, the longitudinal Health ABC study (older adults 70-79 years old) reported an annual decline of 3.6% and 2.8% in men and women, respectively (36). Findings corroborate with previous studies indicating that there is a greater loss in muscle strength than muscle size (30-33). The drastic declines in lower body muscle strength per year contribute to loss of mobility and ultimately decrements in physical function. Muscle power also decreases with age, and the decline occurs at a more rapid rate than that of muscle strength (37). It is estimated

that declines in muscular power are 10% greater than losses in muscular strength in older adults (38). Numerous factors contribute to the loss of muscle power with age, including changes in fiber type, motor unit recruitment, neural factors, and intermuscular coordination (39). Due to the mismatch between declines in muscle strength and muscle size (33) and muscle strength and muscle power (39), investigators have determined that there is also an accompanying decline in muscle quality.

### *Muscle Quality*

One approach to operationalize muscle quality, is defining it as muscle strength per kilogram of body weight or muscle mass (muscle strength/muscle mass (MS/MM)) (40-42). Defined using this criteria, findings indicate that older adults experience a loss of muscle quality during the aging process (43-45), however the underlying mechanisms remain unclear. A recent study suggests that utilizing a measure of muscle power, defined as muscular work per unit time, in the computation of muscle quality (muscle power/muscle mass (MP/MM)) may be a more complex, but more appropriate index (39) and more accurately predict physical function in older adults. Additional studies support the theory that muscle power is a more robust predictor of physical function than muscular strength (46). Muscle power is strongly associated with gait speed (47), balance (48), and functional status (49). Furthermore, muscle power has been found to be more important to activities of daily living than muscle strength (49, 50), as many activities such as stair climbing, lifting one's body from a bed or chair, and carrying groceries, require greater utilizations of muscle power relative to muscle strength. Fewer studies have implemented this approach to define muscle quality; however, it is intuitive that muscle quality using a measure of power (MP/MM) would decline more quickly than

muscle quality using a measure of muscle strength (MS/MM). Provided with the information above, relating physical function and capacity to muscle quality, utilizing an assessment of muscle power, is a novel and appropriate approach.

## **2.6 Physical Functional Changes with Age**

Reductions in habitual physical activity, adverse changes in body composition and declines in capacity measures, including muscle strength and muscle power, are all important factors contributing to declines in physical function in older adults. A contemporary research theme regarding older adults and physical function is determining which component of body composition or capacity measure most strongly contributes to and predicts physical function. Such research endeavors could inform the investigation of effective intervention strategies to prevent physical functional decline in older adults.

Some evidence suggests that adiposity is a stronger contributor to objectively measured lower extremity physical function as compared to lean mass or sarcopenia (35, 35, 51, 52). However, the majority of these studies included older adults who were free of disability or identified as high functioning (53). Still other studies suggest that the amount of lean mass is the strongest predictor of physical function in older adults (54). In particular, Reid et al. reported that increasing leg lean mass by one kilogram decreases the odds of functional limitations by 53%. However, as previously discussed, merely assessing body composition may provide insufficient information to predict physical function.

There remains an inconsistency in the literature regarding which capacity measure best predicts physical function in older adults. Cross-sectional data from NHANES

including 1280 older adults stratified by age, reported that muscle mass, muscle strength, and muscle quality (MS/MM) decreased with age and subsequently, there was also a significant decrease in physical function with age. Furthermore, it was reported that leg strength, in addition to fat mass, was independently associated with physical function, regardless of age and sex. Muscle mass and muscle quality (MS/MM) were not found to be independently associated with physical function in this sample (35). In contrast to these findings, numerous other studies have reported that muscle power is more closely related to physical function and is a better predictor of physical function in older adults (28, 50, 55, 56). More recently, studies have investigated the association between muscle quality and physical function. Misic et al., reported that in a sample of community-dwelling older adults, muscle quality (MS/MM) was the most important predictor of lower extremity physical function, explaining 29-42% of the variance (57). To date, no studies have reported using a measure of muscle quality incorporating muscle power (MP/MM) to predict physical function. In conclusion, it remains unclear which capacity measure or body composition measure most strongly contributes to and predicts physical function in older adults. Findings vary depending on type of assessments employed and physical functional status of participants. In general, it appears that muscle power is the strongest predictor of physical function in mobility-limited older adults whereas adiposity is the strongest predictor of physical function in community-dwelling older adults.

While there are a multitude of studies including lower functioning older adults and similarly a multitude of studies including high functioning older adults, there are a lack of studies incorporating both populations in a single study, utilizing the same standardized methods and procedures. Studies that include individuals across the

functional spectrum could add to the growing literature regarding older adults and physical functional abilities. Moreover, a study including a range of functional abilities may better determine the most accurate predictors of physical function, as it appears that physiological factors contributing to performance-based physical function may differ across the functional spectrum.

## **2.7 Perceived and Performance-Based Physical Function**

As previously discussed, perceived measures of physical function are often used as surrogate measures of performance-based physical function, and vice versa. Perceived measures tend to be subjective and self-report via questionnaire and performance-based measures tend to be objective and involve execution of a specific task that is scored on time, distance, or some other objective factor. Such assessments include the 6 minute walk, 8 foot up and go, Physical Performance Test, and the 30 second chair rise. The most commonly used questionnaire to obtain information regarding one's perception of physical function is the SF-36 physical function scale (SF-36PF). This ten item scale is reliable (58, 59) and well validated in older adults (60, 61). However, the majority of studies report only a moderate correlation between SF-36PF scores and objectively measured physical function, even in a wide variety of populations including healthy, community-dwelling older adults (52, 62), nonagenarians (63), and hip fracture patients (64).

Both perceived and performance-based assessments of physical function have limitations. For example, questionnaires may be inaccurate if an individual answers in such a way that is believed to be expected by the researcher (i.e. social desirability

effect). Also, if the question asks about tasks that the older adult has not completed recently, the individual is forced to offer a best guess and may over or underestimate actual abilities. Performance-based assessments are also not without limitations. For example, performance measures are strongly influenced by a number of non-physiological factors including self-efficacy, perception of safety, previous fall history, motivation to complete the task, etc.

One potential explanation for the lack of higher correlations between perceived and performance-based assessments of physical function are potential mediating factors, such as one's level of physical activity or body composition. Older adults who regularly engage in physical activity may have more accurate assessments of their physical functional abilities and therefore may have stronger correlations between perceived and performance-based measures of physical function. The same relationship may be true with regards to body composition. Older adults who are aware of excessive adiposity or low lean mass may show stronger correlations between perceived and performance-based measures of physical function. Further exploration is warranted in the area of perceived and performance-based physical function in older adults. Such research could improve the efficacy of exercise programs by targeting specific components identified as significantly contributing to objectively measured physical function.

## **2.8 Summary**

In conclusion, the growing number of older adults combined with the obesity epidemic is expected to result in unprecedented levels of functional limitations and physical disability in older Americans. While much research has focused on the

relationships among body composition, capacity measures, and objectively measured physical function, it has yet to be determined which component most strongly contributes to and predicts physical function across the functional spectrum in older adults. One emerging area of interest warranting further exploration is the use of muscle power in the determination of muscle quality and the subsequent relations to physical function. More importantly, there is a need to develop an interdisciplinary approach to studying physical function in older adults inclusive of behavioral factors (i.e. physical activity), psychosocial factors (i.e. perceptions of function, fatigue, self-efficacy, etc.), and physiological factors (i.e. body composition, muscle capacity measures). A more clear understanding of factors that mediate this relationship may elucidate specific strategies and intervention techniques to improve physical function and delay disability in older adults.

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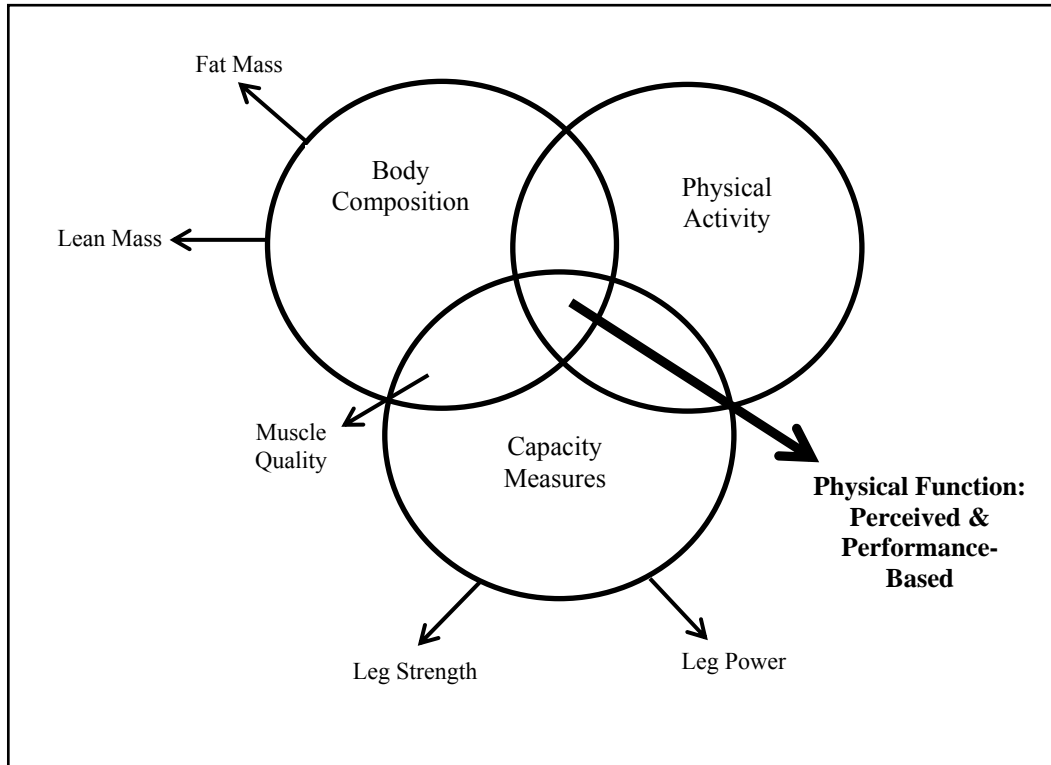
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**Figure 2.1: Conceptual Model: Factors impacting Physical Function in Older Adults**

**CHAPTER 3**

**IMPACT OF MUSCLE QUALITY AND ADIPOSITY ON LOWER EXTREMITY**

**PHYSICAL FUNCTION IN OLDER WOMEN VARYING IN FUNCTIONAL**

**STATUS**

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## **Abstract**

Relations exist among leg strength and power, adiposity, and lower extremity physical function (LEPF) in older women. The primary predictor of LEPF appears to depend on physical functional status with muscle strength and power being a primary contributor in low functioning individuals and adiposity being more important in higher functioning women. Our own data has also determined that muscle quality (MQ), defined as leg strength per unit of leg lean mass, plays a major role in LEPF. This study aimed to explore the utility of a novel expression of MQ (leg power per unit of lower body lean mass) to determine how MQ and adiposity (%Fat) differentially influence LEPF in older women across levels of physical functionality. Women ( $n = 97$ ,  $73.8 \pm 5.6$  yrs, range 65–89 yrs) were assessed for physical activity (PA) via questionnaire, body composition via DXA, leg power via Nottingham power rig, and LEPF using a Physical Performance Test (PPT, score range = 0 to 36), 30 second chair rise (CHR), and 8 foot up and go (UpGo) tasks. As expected, age and total number of medical conditions were associated with variables of interest, thus were statistically controlled. PA (total kcals) was not related to MQ or %Fat ( $p > 0.05$ ). Although a very strong trend, MQ and %Fat were not significantly related ( $r = -0.19$ ,  $p = 0.055$ ). Controlling for age and medical conditions, MQ and %Fat were both related to all three measures of LEPF ( $r$  range =  $-0.48$  to  $0.43$ , all  $p < 0.01$ ,  $r$  range =  $-0.39$  to  $0.35$ , all  $p < 0.05$ , respectively). When grouped via MQ [low ( $< 7.35$  watts/kg), moderate ( $7.35$  to  $9.90$  watts/kg), or high ( $> 9.90$  watts/kg)], high MQ was associated with higher PPT scores in a sequential manner (all  $p < 0.05$ ); however, when grouped by %Fat [low ( $< 38\%$ ), moderate ( $38$  to  $45\%$ ), or high ( $> 45\%$ )], there were no differences in PPT scores ( $p > 0.05$ ) across groups. We conclude that both

MQ and %Fat contribute to LEPF in older women. However, MQ has a stronger relationship to LEPF across functional levels whereas %Fat does not appear to influence LEPF in a graded manner; thus, MQ may be a more important target for exercise interventions than adiposity to preserve LEPF in older women.

**Key words:** physical function, muscle quality, adiposity, older women

### **3.1 Introduction**

The aging process is often accompanied by alterations in body composition, specifically, increases in adiposity and loss of muscle mass. Older adults may simultaneously experience both an increase in fat mass as well as a decline in lean mass, contributing to disordered body composition, placing them at greater risk for declines in physical function. Unfortunately, this depiction of body composition represents a growing proportion of the older adult population (1-5).

One lifestyle factor contributing to changes in body composition with age is an accompanying reduction in habitual physical activity. Regular physical activity in older adults is related to a decrease in chronic health problems, including obesity and sarcopenia (6) and reduced risk of falling (7) in addition to decreased risk of functional limitations (8, 9). Unfortunately, research indicates that older adults are less active than their younger counterparts (10, 11, 12) and tend to engage in fewer activities that require short bursts of high intensity movements, those that depend on muscle power (13). It is currently estimated that less than 18% of older adults engage in any leisure time physical activity (11) and even fewer engage in regular exercise. Furthermore, older women are less likely to engage in leisure time physical activity than men (11).

Alterations in body composition with the aging process strongly impact physical function. Specific to adiposity, higher levels of body fat mass are associated with mobility limitations (1, 14) and reductions in lean mass are associated with declines in muscular strength, muscular power, and muscular endurance. Declines in physical function further contribute to increased disability, loss of independence, increased fall

risk, and mortality (15-18). It is unclear whether increases in adiposity or decreases in lean mass more strongly impact physical function in older adults.

The primary body composition predictor of lower extremity physical function (LEPF) appears to depend on physical functional status. Ample literature supports the concept that high adiposity is the strongest body composition contributor to physical function in high functioning older women without functional limitations (19, 20). However, in studies involving women of lower functional status, amount of lean mass appears to be the strongest body composition contributor to physical function (21). Capacity measures, such as leg strength and power impact physical function as much or more than body composition measures alone. More recently, the concept of muscle quality (MQ) has been investigated as a predictor of LEPF. A functional approach to define MQ traditionally involves a ratio of leg muscle strength to body weight or lean mass (22-24). In studies involving generally healthy older adults, it is unclear whether body composition, capacity measures, or a combination of these factors, such as MQ, has the greatest impact on physical function as conflicting findings have been reported: a) leg strength and fat mass, but not muscle mass or MQ, are associated with physical function (25), and b) MQ is the most salient predictor of physical function, more so than muscular strength or aerobic fitness (26). However, with regards to leg power, it is consistently reported that older adults with low physical function exhibit lower leg power when compared to higher functioning older adults (27, 28).

It is evident that findings are inconsistent regarding the influence of body composition and capacity measures on physical function in older adults. Therefore, the interaction between body composition and a capacity measure, specifically muscle

power, may be useful in better understanding physical function in older women across the functional spectrum. Based on the consistent findings of negative correlations between leg power and LEPF, and the relation between body composition and LEPF, the aim of the current study was to explore the novel expression of MQ (leg power per unit of lower body lean mass) to determine how MQ and adiposity (%Fat) differentially influence LEPF in older women across levels of physical functionality. It was hypothesized that 1) both MQ and %Fat would be significantly correlated with LEPF across all levels of functionality in older women, and 2) both MQ and %Fat will exert a dose-response relationship with LEPF in older women across the functional spectrum, with the highest functioning women having the highest MQ and lowest %Fat.

### **3.2 Materials and Methods**

#### *Participants*

Ninety-seven older women ( $73.9 \pm 5.5$  years, range 65–89 years) participated in the study. Exclusion criteria included the presence of uncontrolled health conditions including angina and hypertension ( $> 160/90$  mmHg), diabetes, metabolic, cardiovascular, or pulmonary disease, or the presence of cognitive deficiencies.

Following screening, all participants completed a university Institutional Review Board approved informed consent prior to participation in the study. This study used a cross-sectional design. Participants completed all testing measures in one session, lasting approximately three hours in duration.

### *Physical Activity*

Physical activity was determined using the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire (29), which assesses weekly frequency and duration of physical activity in older adults over the past month. The questionnaire includes 41 questions regarding a variety of activities and the responses are scored to yield the following estimates: 1) total caloric expenditure per week in all activities, 2) total caloric expenditure per week in activities of at least moderate intensity (MET value of 3.0 or greater), 3) frequency per week of all activities, and 4) frequency per week in activities of at least moderate intensity (MET value of 3.0 or greater). Physical activity was expressed and analyzed utilizing two different methods. First, to gain insight regarding the relationship between physical function and total amounts of physical activity or caloric expenditure, physical activity was expressed as total caloric expenditure per week in all activities. Second, to gain insight regarding the relationship between physical function and physical activity behaviors known to influence physical function and to eliminate body weight as a potential confounder, physical activity was expressed as total moderate or greater MET-hours per week. Research has indicated activities of moderate intensity or greater are most likely to impact physical function (30) and have less error associated with self-report measures as planned, structured physical activity of at least moderate intensity is easier to recall than low intensity activities (31).

### *Body Composition*

Standing height and weight were measured with subjects wearing light-weight clothing and no shoes. Height was obtained using a stadiometer (Seca, Model 242) with measures obtained to the nearest 0.1 cm. Weight was measured on a calibrated digital

scale (Tanita, Model WB-110A). Body Mass Index (BMI) was calculated by dividing body mass (kg) by height (m) squared  $[(\text{kg})/\text{ht}(\text{m})^2]$ . Body composition, including whole body and regional soft tissue, was measured by dual-energy X-ray absorptiometry (iDXA, GE Healthcare-Luna, Madison, WI.). The software allows for isolation of a specific region of interest, and lower body lean mass was quantified as the total lean mass below the top of the iliac crest.

### *Leg Power*

Leg power was measured using a Nottingham Power Rig. The device measures explosive power in a single leg extension against an unloaded pedal which is attached to a flywheel. Prior to assessment, the seat position was adjusted for leg length to allow for a 5 degree bend at the knee joint when the leg is at full extension. Participants were instructed to keep their arms folded across their chest with the inactive leg flexed at 90 degrees and the foot relaxed on the floor. The leg being tested rests on the pedal, supported by a magnetic latch. Participants were then instructed to push the pedal as hard and as fast as possible. Rest periods of 30 seconds were allowed between each trial, with participants performing up to ten trials. The final velocity of the flywheel was used to calculate the average output, expressed in watts. The highest obtained value was used for analysis. Both the dominant and non-dominant legs were tested. This method has been validated against isokinetic dynamometry and two-legged jumps on a force plate (32, 33) and reported to be relevant to everyday activities such as stair climbing and rising from a chair.

### *Muscle Quality*

Peak power values for each leg were added together to obtain total lower body power in watts. Lower body lean mass, obtained from iDXA measures, was calculated as the sum of the total lean mass in the gluteal muscles, quadriceps, hamstrings, and gastrocnemius. MQ was thereby expressed as leg power (watts) divided by lower body lean mass (kg), (watts/kg).

### *Lower Extremity Physical Function*

LEPF was assessed using a battery of tests including the Physical Performance Test (PPT), a 30 second chair rise (CHR), and an 8 foot up and go (UpGo). The PPT, a well validated measure in older adults (34, 35), consists of eight tasks assessing both upper and lower body physical function, including a series of progressive balance poses, chair rise, book lift, jacket task, penny retrieval, 360 degree turn, 50 foot walk, and stair climb. In the CHR task, participants completed as many repeated chair rises as possible during a 30 second time period. Each participant completed an UpGo test, in which a cone was placed 8 feet away from a chair. Starting in the seated position, participants were instructed to stand, walk around the cone and return to a seated position as quickly as possible, after the word “go.”

### *Statistical Analyses*

Data were analyzed with PASW for Windows version 19.0 (SPSS, Inc., Chicago, IL.). Data were assessed for normal distribution and means and standard deviations were calculated for all participant characteristics and primary outcome variables. Distribution statistics were computed to ensure data were normally distributed. One participant was a statistical outlier (greater than four standard deviations from the mean) with regards to

moderate MET-Hours and was therefore excluded from all analyses involving moderate MET-Hours. All remaining analyzed data were normally distributed. Pearson correlations were used to determine the strength of relationship between participant characteristics (age, BMI, medical conditions), body composition (%Fat, lower body lean mass), physical activity (PA), and capacity measures (leg power, MQ).

Partial correlation analyses, controlling for age, medical conditions, and moderate MET-Hours were used to examine the relations between primary outcome measures of interest (MQ and %Fat) and LEPF. To test whether MQ and %Fat exhibited a dose-response relationship on LEPF, individuals were grouped using two different strategies. First, tertiles were established for MQ [low (< 7.35 watts/kg), moderate (7.35 to 9.90 watts/kg), or high (> 9.90 watts/kg)] and %Fat [low (< 38%), moderate (38 to 45%), or high (> 45%)]. Secondly, the participants were stratified based on PPT score [low function (PPT < 30), moderate function (31 to 33), or high function (34 to 36)]. Controlling for age and medical conditions, an ANCOVA was performed to assess differences in a) PPT across MQ and %Fat groups and b) MQ and %Fat across PPT groups, with post hoc Least Significant Difference, to assess differences between groups. All significance tests were conducted at the  $p \leq 0.05$  level.

The primary aim targeted the relation between functional status and MQ or %Fat. Thus, the power analysis determined that with 30 participants per tertile group the study would have 80% power to detect statistically significant differences, assuming Cohen d effect size of 0.65, among the MQ and %Fat tertile groups, at an alpha level of 0.05.

### 3.3 Results

Subject characteristics are presented in Table 3.1. On average, participants were  $73.8 \pm 5.6$  years old and had a BMI of  $26.6 \pm 4.7$ , indicating that on average our participants were overweight. The sample was 94% white, 5% black, and 1% Asian. The mean caloric expenditure in physical activities for the participants was  $3120.4 \pm 2093.6$  kcals per week, with an average of 22.9 hours of moderate or greater intensity physical activity per week. The average number of medical conditions was  $2.1 \pm 1.2$ , which included the following self-reported conditions: cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease, other conditions (sleep apnea, cancer, and epilepsy). The most common medical conditions were arthritis ( $n = 66, 68\%$ ), other co-morbidities including cancer, sleep apnea, or epilepsy ( $n = 66, 68\%$ ) and hypertension ( $n = 43, 44\%$ ).

As expected, age was significantly related to primary outcome variables (MQ and %Fat), as well as LEPF including leg power, PPT score and UpGo time (Table 3.2a). Total number of medical conditions was significantly correlated with primary outcome variable, MQ, in addition to LEPF including leg power, PPT, and UpGo time. Therefore, age and medical conditions were statistically controlled for in subsequent analyses. Neither age nor medical conditions were correlated with total kcals or moderate MET-Hours. Controlling for age and medical conditions, the two primary outcome variables (%Fat and MQ) were not significantly related ( $r = -0.19, p > 0.05$ ). Total kcals was not significantly related to %Fat, MQ, or any measures of LEPF. Moderate MET-Hours was significantly related to %Fat ( $r = -0.27, p < 0.01$ ), MQ ( $r = 0.30, p < 0.01$ ) and LEPF including leg power, CHR, UpGo, and PPT ( $r$  range =  $-0.28$  to  $0.30$ , all  $p < 0.01$ ). Due to

the significant associations between moderate MET-Hours and LEPF, age, medical conditions, and PA were controlled for in analyses involving PA expressed as moderate MET-Hours.

#### *Relations Between Muscle Quality and Lower Extremity Physical Function*

MQ was significantly related to all measures of LEPF, when controlling for age and medical conditions (Table 3.2b). An inverse relationship existed between MQ and UpGo time ( $r = -0.48$ ,  $p < 0.01$ ), and a positive relationship existed between MQ and PPT score and MQ and CHR ( $r = 0.43$ ,  $p < 0.01$  and  $r = 0.48$ ,  $p < 0.01$ , respectively). When controlling for age, medical conditions, and moderate MET-Hours, MQ remained significantly related to all measures of LEPF (Table 3.2c). Results comparing PPT scores across MQ groups [low ( $< 7.35$ ), moderate (7.35 to 9.90), or high ( $> 9.90$ )] are shown in Figure 3.1. Controlling for age and medical conditions, statistical differences were found across all three MQ groups with individuals in the high MQ group scoring higher on the PPT than either of the moderate or low MQ groups and the moderate MQ group scoring higher on the PPT than the low MQ group (all  $p < 0.05$ ). Controlling for age, medical conditions, and moderate MET-Hours, statistical differences were found across low to high MQ groups ( $p=0.001$ ), but not across low to moderate ( $p=0.056$ ) and moderate to high ( $p=0.094$ ) MQ groups. Inversely, controlling for age and medical conditions, statistical differences were found across all three PPT groups [low ( $\leq 30$ ), moderate (31-33), or high ( $> 33$ )] with high functioning individuals having greater MQ than both the moderate or low function group and the moderate functioning group having greater MQ than the low functioning group (all  $p < 0.05$ ).

### *Relations Between Adiposity and Lower Extremity Physical Function*

Percent fat was significantly related to all measures of LEPF, when controlling for age and medical conditions (Table 3.2b). Higher %Fat was associated with lower PPT and lower CHR ( $r = -0.24$ ,  $p = .02$ ,  $r = -0.39$ ,  $p < 0.01$ , respectively). Conversely, individuals with higher %Fat had a slower UpGo time ( $r = 0.35$ ,  $p < 0.01$ ). When controlling for age, medical conditions, and moderate MET-Hours, %Fat remained significantly related to all measures of LEPF (Table 3.2c). Results comparing PPT scores across %Fat groups [low (< 38%), moderate (38 to 45%), or high (> 45%)] are shown in Figure 3.2. Controlling for age and medical conditions, there were no statistical differences in PPT scores across %Fat groups; however, subjects in the lowest %Fat group had the highest PPT scores ( $32.4 \pm 3.1$ ) in comparison to the moderate %Fat group ( $32.2 \pm 3.3$ ) and high %Fat group ( $31.6 \pm 3.0$ ). Controlling for age, medical conditions, and moderate MET-Hours, no statistical differences were found in PPT scores across %Fat groups ( $p = 0.556$ ). Controlling for age and medical conditions, there were no statistical differences in %Fat across PPT groups; however, subjects in the lowest PPT group had the highest percent fat ( $42.3 \pm 7.1\%$ ) in comparison to the moderate PPT group ( $42.1 \pm 7.6\%$ ) and high PPT group ( $40.8 \pm 6.1\%$ ).

### **3.4 Discussion**

This study explored a novel approach to defining MQ and explores how this capacity measure, in addition to adiposity, relates to LEPF in older women. The data support findings that both adiposity and MQ are related to LEPF. However the novel

finding is that MQ appears to exert a dose-response impact on LEPF across functional status, whereas %Fat does not.

The study expands the growing body of literature attempting to determine the most salient body composition and/or muscle capacity correlates of physical function in older women. Our data suggests that the functional declines that accompany the aging process are strongly related to the loss of lean mass, regardless of one's level of adiposity, at least in ambulatory, older women. From a muscle biology perspective, declines in muscle mass further contribute to declines in leg power, often stemming from lifestyle changes, specifically a decrease in PA that is of moderate intensity or greater, contributing to changes in muscle contractile properties and neuromuscular activation (28). A recent review by Reid and colleagues determined that muscle power is a more discriminant predictor of physical function than muscle mass or muscle strength, highlighting the need to assess capacity measures, specifically leg power, in older adults in addition to determining body composition (28). In agreement with Reid et al. (28), our data support a robust relationship between leg power and physical function.

To our knowledge, this is one of the first studies to utilize leg power in the calculation of MQ. It is well accepted that muscle power declines more quickly than either muscle mass or muscle strength in older adults (28, 36), thereby indicating that the ability to generate a strong force over a short amount of time, may be the limiting factor in functional abilities (28). For example, many activities of daily living require a burst of power, such as stair climbing, rising from a chair, and carrying groceries. In addition, the prevention of falls, a major risk factor for physical disability, requires an older adult to generate an adequate amount of strength within a short period of time. A recent report by

Barbat-Artigas and colleagues proposes that MQ is an innovative approach to assess physical function in a clinically meaningful manner and that the utilization of muscle power as opposed to muscle strength allows for a more complete index of MQ (36). The data from the current study support the use of leg power in the definition of MQ in its ability to distinguish across levels of physical functionality in older women. Our data represent a contemporary contribution to the literature as it suggests that targeting MQ, specifically maintenance of leg power and lean mass, during exercise and/or nutrition/weight loss interventions may be important in preserving LEPF in older women.

The current study supports previous studies reporting that adiposity is a robust predictor of physical function among older adults. For example, a recent review article by Shin and colleagues reported that in community-dwelling older adults, a body of literature supports the predictive ability of adiposity on physical function (37); whereas, lean mass was not a predictor of physical function in community-dwellers (38, 39). However, in contrast to previous studies, the current study found that adiposity is associated with physical function in older women across the functional spectrum; however, the relationship is not apparent in women with high physical function capability. Moreover, in contrast to our hypothesis, we found no dose-response relationship of adiposity on level of physical function in our sample of older women.

Developing specific interventions to maintain physical function in older adults is imperative as it is predicted that the typical older adult will be sarcopenic-obese, the somatotype most at risk for physical disability and functional declines (1-5). Interventions must focus not only on preventing gains in or reducing adiposity, but the preservation of leg power, especially as expressed as MQ. Several interventions have

evaluated the effectiveness of power training on physical function in older adults in comparison to traditional resistance training. In addition to gaining leg power during the intervention, older adults displayed improved performance during whole body functional tasks (40, 41). It appears that power training may have a greater effect on physical function in individuals with lower functional abilities; however, based on the findings from the current study, MQ exerts a dose-response on LEPF, implying that maintenance of MQ is vital across all levels of functionality.

Although our data are of contemporary interest, the current study is not without limitations. While the sample population is representative of the general population of older women, with regards to medical conditions and obesity, the majority of participants were community-dwelling and relatively independent. Additionally, our study did not include an objective measure of PA, such as accelerometry, which may have increased the sensitivity of the PA measurement. Finally, although commonly used in the literature, muscle strength via dynamometer was not obtained. Future work should include comparative measures of muscle strength.

In conclusion, our data suggest that the preservation of lean mass and muscle power are essential to maintain adequate physical function in older women. The contribution of adiposity to LEPF remains important, yet does not appear to exert a dose-response effect on LEPF across the functional spectrum. Defining MQ using the novel definition of leg power per unit of lower body lean mass may serve as a new method to differentiate older women of varying levels of functionality. A more clear understanding of the interactions among MQ, adiposity and LEPF could have major public health implications by informing the development of exercise, nutrition, or weight loss

interventions in order to be most efficacious to exert a clinically-meaningful impact on mobility and physical function in older women.

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**Table 3.1** Participant characteristics

Characteristics (n = 97)	Range	Mean $\pm$ SD
Age (years)	65 - 89	73.8 $\pm$ 5.6
Height (meters)	1.5 - 1.9	1.7 $\pm$ 0.1
Weight (kilograms)	38.5 - 106.5	69.2 $\pm$ 12.8
BMI (kg/m <sup>2</sup> )	16.1 - 45.3	26.6 $\pm$ 4.7
Total Medical Conditions <sup>a</sup>	0 - 6	2.1 $\pm$ 1.2
CHAMPS (kcal) <sup>b</sup>	0 - 10480.5	3120.4 $\pm$ 2093.6
Moderate MET-Hrs <sup>†</sup>	0 - 88.2	22.9 $\pm$ 20.9
Adiposity (%Fat)	21 - 55.8	41.6 $\pm$ 6.8
Leg power (watts)	73.6 - 333.1	184.1 $\pm$ 5.9
Muscle quality (watts/kg)	4.2 - 16.2	9.1 $\pm$ 2.8
CHR <sup>c</sup>	0 - 23	12.3 $\pm$ 4.4
Up Go (seconds) <sup>d</sup>	3.3 - 12.6	7.0 $\pm$ 1.6
PPT total score <sup>e</sup>	22 - 36	32.1 $\pm$ 3.1

<sup>a</sup>Total self-report medical conditions including cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease, other conditions (sleep apnea, cancer, epilepsy); <sup>b</sup>Community Healthy Activities Model Program for Seniors; <sup>c</sup>30 second chair rise; <sup>d</sup>8 foot up-and-go; <sup>e</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function).

<sup>†</sup> n = 96

**Table 3.2a** Correlations between age, medical conditions, and outcome variables, (n = 97)

	Total Medical Conditions <sup>a</sup>	CHAMPS (kcal) <sup>b</sup>	Moderate MET-Hrs <sup>†</sup>	Adiposity (%Fat)	Leg power (watts)	Muscle quality (watts/kg)	CHR <sup>c</sup>	Up Go (seconds) <sup>d</sup>	PPT total score <sup>e</sup>
Age (years)	0.20	0.00	-0.04	-0.29**	-0.51**	0.49**	-0.12	0.43**	0.36**
Total Medical Conditions <sup>a</sup>		-0.11	-0.18	0.14	-0.29**	-0.28**	-0.13	0.26*	-0.22*
CHAMPS (kcal) <sup>b</sup>			0.87**	-0.07	0.20	0.10	0.11	-0.19	0.11
Moderate MET-Hrs <sup>†</sup>				-0.28**	0.30**	0.27*	0.33**	-0.29**	0.29**
Adiposity (%Fat)					0.05	-0.05	-0.35**	0.20	-0.13
Leg power (watts)						0.92**	0.38**	-0.56**	0.46**
Muscle quality (watts/kg)							0.48**	-0.61**	0.54**
CHR <sup>c</sup>								-0.59**	0.69**
Up Go (seconds) <sup>d</sup>									-0.69**

\* Significant correlation at  $p < 0.05$ ; \*\* Significant correlation at  $p < 0.01$ ; <sup>†</sup>n = 96

<sup>a</sup>Total self-report medical conditions including cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease, other conditions (sleep apnea, cancer, epilepsy); <sup>b</sup>Community Healthy Activities Model Program for Seniors; <sup>c</sup>30 second chair rise; <sup>d</sup>8 foot up-and-go; <sup>e</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function).

**Table 3.2b** Partial correlations between physical activity, adiposity, muscle quality, and physical function, (n = 97)

	Moderate MET- Hrs <sup>†</sup>	Adiposity (%Fat)	Leg power (watts)	Muscle quality (watts/kg)	CHR <sup>b</sup>	Up Go (seconds) <sup>c</sup>	PPT total score <sup>d</sup>
CHAMPS (kcal) <sup>a</sup>	0.87**	-0.05	0.21*	0.10	0.10	-0.20	0.11
Moderate MET-Hrs <sup>†</sup>		-0.27**	0.30**	0.26*	0.31**	-0.28**	0.28**
Adiposity (%Fat)			-0.08	-0.19	-0.39**	0.35**	-0.24*
Leg power (watts)				0.89**	0.36**	-0.42**	0.32**
Muscle quality (watts/kg)					0.48**	-0.48**	0.43**
CHR <sup>b</sup>						-0.60**	0.69**
Up Go (seconds) <sup>c</sup>							-0.63**

All correlations controlled for age and total number of medical conditions

\* Significant correlation at  $p < 0.05$ ; \*\* Significant correlation at  $p < 0.01$ ; <sup>†</sup>n = 96

<sup>a</sup>Community Healthy Activities Model Program for Seniors; <sup>b</sup>30 second chair rise; <sup>c</sup>8 foot up-and-go; <sup>d</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function).

**Table 3.2c** Partial correlations between adiposity, muscle quality, and physical function, (n = 96)

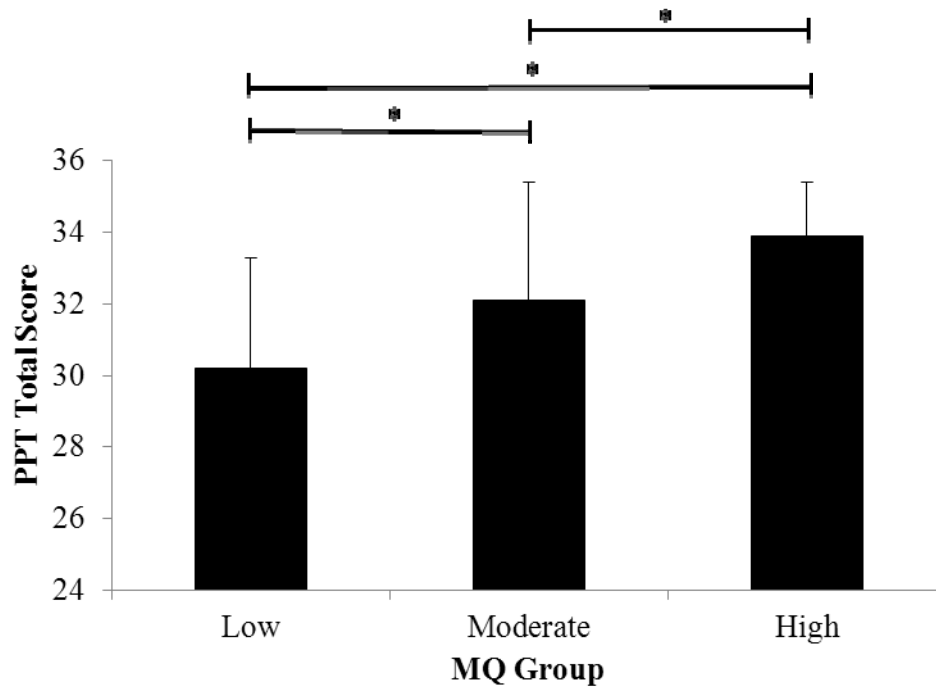
	Muscle quality (watts/kg)	CHR <sup>b</sup>	Up Go (seconds) <sup>c</sup>	PPT total score <sup>d</sup>
Adiposity (%Fat)	-0.16	-0.36**	0.32**	-0.20*
Leg Power (watts)	0.88**	0.27**	-0.39**	0.25*
Muscle quality (watts/kg)		0.43**	-0.47**	0.38**
CHR <sup>b</sup>			-0.58**	0.67**
Up Go (seconds) <sup>c</sup>				-0.62**

All correlations controlled for age, total number of medical conditions, and moderate MET-Hours.

\* Significant correlation at  $p < 0.05$ ; \*\* Significant correlation at  $p < 0.01$ .

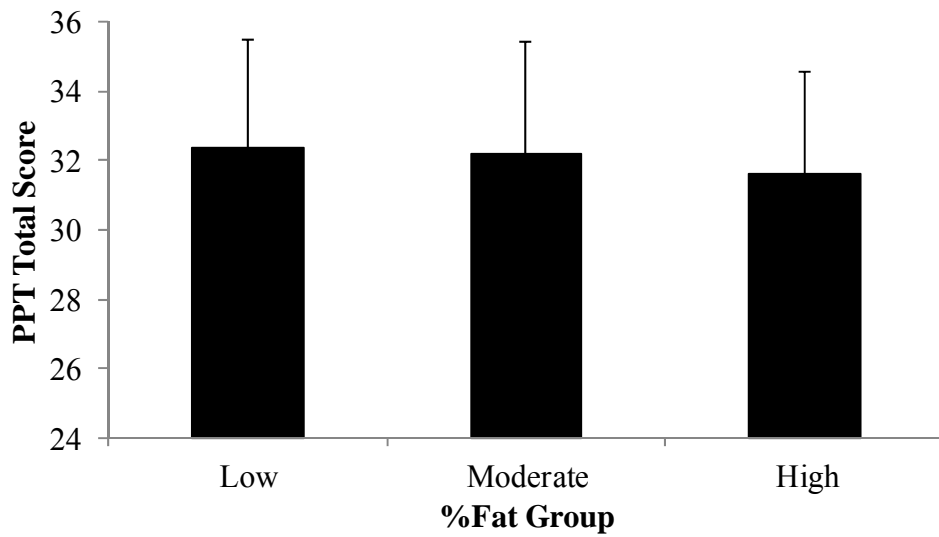
<sup>a</sup>Community Healthy Activities Model Program for Seniors; <sup>b</sup>30 second chair rise; <sup>c</sup>8 foot up-and-go;

<sup>d</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function); <sup>e</sup>6 minute walk test; <sup>f</sup>Short-form-36 Physical function scale (scores range from 0 to 100, with higher scores representing the absence of perceived physical function limitations).



**Figure 3.1.** Mean PPT values across MQ groups [low (< 7.35 watts/kg), moderate ( $7.35 \leq \text{MQ} \leq 9.90$  watts/kg), or high ( $\text{MQ} > 9.90$  watts/kg)]. Values are means  $\pm$  SD; controlled for age and medical conditions.

\*  $p < 0.05$  represents statistical differences in group means.



**Figure 3.2.** Mean PPT values across %Fat groups [low (%Fat < 38), moderate ( $38 \leq \%Fat \leq 45$ ), or high (%Fat > 45)]. Values are means  $\pm$  SD; controlled for age and medical conditions. No statistically significant differences were found across %Fat groups.

**CHAPTER 4**

**INFLUENCE OF PHYSICAL ACTIVITY, ADIPOSITY, AND MUSCLE  
QUALITY ON PERCEIVED AND PERFORMANCE-BASED PHYSICAL  
FUNCTION IN OLDER WOMEN**

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<sup>2</sup>O'Brien, A.E., Evans, E.M. To be submitted to *The Gerontologist*

## **Abstract**

Moderate correlations exist between perceived physical function (PF) and performance-based PF in older women. Additionally, relations exist among physical activity (PA), adiposity (%Fat), muscle quality (MQ), and performance-based (PF) in older women. This study aimed to explore the impact of PA, %Fat, and MQ on perceived PF in older women across levels of self-reported PF. Women ( $n = 97$ ,  $73.8 \pm 5.6$  yrs, range 65–89 yrs) were assessed for physical activity (PA) via questionnaire, adiposity (%Fat) via DXA, muscle power via Nottingham leg power rig which was used to calculate MQ (leg power in watts per unit of lower body lean mass), perceived physical function (PF) via SF-36PF questionnaire, and performance-based PF using a battery of tests including Physical Performance Test (PPT, score range = 0 to 36), 30 second chair rise (CHR), 8 foot up-and-go (UpGo), and 6 minute walk test (6MWT). As expected, age and total number of medical conditions were associated with variables of interest, thus were statistically controlled. The two primary outcome variables (SF-36PF and performance-based PF measures) were significantly related. An inverse relationship existed between SF-36PF and UpGo time ( $r = -0.41$ ,  $p < 0.01$ ), and a positive relationship existed between SF-36PF and PPT, CHR, and 6MWT ( $r = 0.41$ ,  $r = 0.34$ ,  $r = 0.52$ , all  $p < 0.01$ , respectively). PA was significantly related to SF-36PF ( $r = 0.33$ ,  $p < 0.01$ ). Comparing PA to performance-based PF measures, PA was significantly related to all assessments [UpGo, PPT, CHR, and 6MWT ( $r = -0.28$ ,  $r = 0.28$ ,  $r = 0.31$ ,  $r = 0.39$ , all  $p < 0.01$ , respectively)]. When grouped by SF-36PF scores [low ( $\leq 65$ ), moderate (66–85), or high ( $>85$ )], higher perception of PF was associated with lower %Fat, higher MQ, and greater PA. Age, medical conditions, PA, %Fat, and MQ were independent predictors of

perceived PF, explaining 37.7% of the total variance; whereas, MQ and PA were the only independent predictors of performance-based PF, explaining 30.9% of the total variance. We conclude that PA, %Fat, and MQ significantly contribute to perceived PF in older women, and that perceived and performance-based PF may assess different dimensions of PF; therefore, it is recommended to assess PF of older women via self-report or perception in addition to performance-based tasks.

**Key words:** perceived physical function, performance-based physical function, older women

## 4.1 Introduction

The assessment of physical function (PF) in older adults can take many forms, yet the most common include self-report and objectively measured PF. Generally, self-report or perceived PF is assessed via questionnaires and objective function is assessed through the performance of specific tasks that are quantifiable and provide a score based on time, weight, or distance. Objective measures of PF in older adults include a variety of tasks such as the 6 minute walk, 30 second chair rise, and the 8 foot up and go. The Short-Form 36 is the most widely used measure of self-reported, health-related quality of life and within this questionnaire, the physical function scale (SF-36PF) is often used to compare against objective measures of PF. Depending on time and resources, perceived and performance-based measures are often used interchangeably, despite only a moderate correlation between the two measures. Numerous studies have compared perceived and performance-based PF in older adults (1-4). There is much variability in correlations between these measures ranging from 0.22 (5) to 0.73 (6). Due to inconsistent findings in this area, it is generally recommended to assess PF of older adults using both self-report and performance-based measures (6, 7). However, this approach may not be feasible due to expense and time.

One plausible explanation for the lack of stronger correlations between measures of perceived and performance-based PF in older adults is the influence of mediating factors. While possible mediating factors such as self-efficacy have been investigated in the literature (3), the influence of physiological and behavioral variables have yet to be explored. Potential physiological mediating factors may include body composition, including adiposity (%Fat), and capacity measures, such as muscle quality (MQ). A

potential behavioral variable mediating this relationship may include an individual's level of physical activity (PA). PA, body composition, and MQ are known to be related to performance-based PF (8-14), but less is known about their relationship to perceptions of PF in older adults. Furthermore, previous studies have indicated that the influence of these physiological and behavioral variables (PA, %Fat, and MQ) on performance-based PF may have differential implications depending on an individual's level of functionality (9, 10). It is unknown if this dose-response relationship exists when comparing the physiological and behavioral variables across levels of perceived PF. A contemporary literature is developing that aims to determine how physiological and behavioral variables predict PF in older adults in order to design the most efficacious PA interventions. Relatedly, this same research relating physiological and behavioral variables to perceived PF could benefit the development of PA interventions; however this has yet to be explored in the literature.

The aims of the current study were 1) to determine the relationship between behavioral and physiological variables (PA, %Fat, and MQ) and perceived PF (SF-36PF), 2) to determine how PA, %Fat, and MQ differentially impact perceived PF in older women varying in functional capacity, 3) to determine the independent contribution of PA, %Fat, and MQ to both perceived and performance-based PF in older women. It was hypothesized that 1) moderate correlations will exist between PA, %Fat, and MQ and perceived PF, 2) PA, %Fat, and MQ will exert a dose-response relationship on perceived PF in older women across the functional spectrum, with women reporting the highest perception of PF reporting the greatest amounts of PA, having the lowest %Fat and

highest MQ, and, 3) PA, %Fat, and MQ will independently contribute to both perceived and performance-based PF in older women.

## **4.2 Materials and Methods**

### *Participants*

Ninety-seven older women ( $73.9 \pm 5.5$  years, range 65–89 years) participated in the study. Exclusion criteria included the presence of uncontrolled health conditions including angina and hypertension ( $> 160/90$  mmHg), diabetes, metabolic, cardiovascular, or pulmonary disease, or the presence of cognitive deficiencies. Following initial screening all participants completed a university Institutional Review Board approved informed consent prior to participation in the study. The study was a cross-sectional design. Participants completed all testing measures in one session, lasting approximately three hours in duration.

### *Physical Activity*

PA was determined using the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire (15), which assesses weekly frequency and duration of PA in older adults over the past month. The questionnaire includes 41 questions regarding a variety of activities and the responses are scored to yield the following estimates: 1) total caloric expenditure per week in all activities, 2) total caloric expenditure per week in activities of at least moderate intensity (MET value of 3.0 or greater), 3) frequency per week of all activities, and 4) frequency per week of activities of at least moderate intensity (MET value of 3.0 or greater). In order to gain insight regarding the relationship between physical function and physical activity behaviors

known to influence physical function and to eliminate body weight as a potential confounder, physical activity was expressed as total moderate or greater MET-hours per week. Research has indicated activities of moderate intensity or greater are most likely to impact physical function (16) and have less error associated as planned, structured physical activity of at least moderate intensity is easier to recall than low intensity activities (17).

### *Body Composition*

Standing height and weight were measured with subjects wearing light-weight clothing and no shoes. Height was obtained using a stadiometer (Seca, Model 242) with measures obtained to the nearest 0.1 cm. Weight was measured on a calibrated digital scale (Tanita, Model WB-110A). Body Mass Index (BMI) was calculated by dividing body mass (kg) by height (m) squared [(kg)/ht(m)<sup>2</sup>]. Body composition including whole body and regional soft tissue was measured by dual-energy X-ray absorptiometry (iDXA, GE Healthcare-Luna, Madison, WI.).

### *Physical Function*

Performance-based PF was assessed using a battery of tests including the Physical Performance Test (PPT), a 30 second chair rise (CHR), an 8 foot up and go (UpGo), and a six minute walk test (6MWT). The PPT, a well validated measure in older adults (18,19), consists of eight tasks assessing both upper and lower body PF, including a series of progressive balance poses, chair rise, book lift, jacket task, penny retrieval, 360 degree turn, 50 foot walk, and stair climb. In the CHR task, participants completed as many repeated chair stands as possible during a 30 second time period. Each participant completed an UpGo test, an assessment of balance and agility, in which a cone is placed

8 feet away from a chair. Starting in the seated position, participants were instructed to stand, walk around the cone and return to a seated position as quickly as possible, after the word “go.” The 6MWT was performed to assess cardiorespiratory endurance.

During the test, individuals were instructed to cover as much ground as possible during the six minutes. Cones were set up in a hallway, for a standard lap of 80 meters total.

Perceived PF was assessed using the Physical Function scale from the Short Form-36 questionnaire (SF-36 PF). The questionnaire inquires about ten tasks that range in difficulty from bathing and dressing to vigorous activities, such as running, lifting heavy objects, or participating in strenuous sports. Individuals indicate whether their health has limited them in the past month in completing these tasks by choosing one of the following responses: 1) yes, limited a lot, 2) yes, limited a little, or 3) no, not limited at all. Scores range from 0 to 100 with higher scores indicating the absence of perceived limitations or disabilities. The SF-36PF scale has been found to be valid (20, 21) and reliable in an older adult population (22, 23).

### *Statistical Analyses*

Data were analyzed with PAWS for Windows version 19.0 (SPSS, Inc. Chicago, IL.). Data were assessed for normal distribution and means and standard deviations were calculated for all participant characteristics and primary outcome variables. Distribution statistics were computed to ensure data were normally distributed. One participant was a statistical outlier (greater than four standard deviations from the mean) with regards to physical activity (moderate MET-Hours) and was therefore excluded from all analyses involving physical activity. All remaining analyzed data were normally distributed. Pearson correlations were used to determine the strength of relationship between

participant characteristics (age, BMI, medical conditions, %Fat), PA and PF measures (PPT, UpGo, 6MWT, CHR, SF-36PF).

Partial correlations, controlling for age and medical conditions, were used to examine the relations between perceptions of physical function (SF-36PF) and performance-based PF. Additional partial correlations were used to evaluate the relationship between PA, %Fat, MQ and perceived PF, all controlled for age and medical conditions.

To test whether differences existed in level of PA, %Fat, or MQ among perceptual levels of PF, individuals were grouped based on SF-36PF scores: low ( $30 \leq \text{SF-36PF} \leq 65$ ), moderate ( $66 < \text{SF-36PF} \leq 85$ ), or high ( $86 < \text{SF-36PF} \leq 100$ ). Cut points for SF-36PF were determined based on previous research (24-26). Controlling for age and medical conditions, an ANCOVA was performed to determine if differences in PA, %Fat, and MQ existed across SF-36PF groups, with post hoc Least Significant Difference, to assess differences between SF-36PF groups.

To determine the strongest independent predictors of both perceived (SF-36PF) and performance-based physical function (PPT), a forward purposeful selection technique was employed to create a multivariate regression model. Independent variables were entered into the model based on the strength of bivariate correlations with the dependent variable, such that those with higher values were entered first. The PPT was chosen as the primary PF outcome for multivariate regression analysis as it includes both upper and lower body tasks and aligns more closely with questions contained within the SF-36PF. Alpha was set at 0.10 for inclusion in the final models due to the exploratory nature of the analysis and the limited sample size.

The primary aim targeted the relation among perception of PF and MQ or %Fat. Thus, the power analysis determined that with 30 participants per tertile group, the study would have 80% power to detect statistically significant differences, assuming a medium to large effect size (Cohen d of 0.65), among the three SF-36PF groups in MQ and %Fat, at an alpha level of 0.05. Similarly, it was determined that with 88 participants total, the study would have 90% power to detect a statistically significant correlation between variables of interest (SF-36PF and PPT), assuming a medium effect size (equivalent to a correlation of 0.24 or a Cohen d of 0.50) at an alpha of 0.05.

### **4.3 Results**

Subject characteristics are presented in Table 4.1. On average, participants were  $73.8 \pm 5.6$  years old and had a BMI of  $26.6 \pm 4.7$ , indicating that the women on average were classified as overweight. The sample was 94% white, 5% black, and 1% Asian. The mean moderate MET-Hours per week was 22.9. The average number of medical conditions was  $2.1 \pm 1.2$ , which included the following self-reported conditions: cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease, other conditions (sleep apnea, cancer, and epilepsy). The most common medical conditions were arthritis (n=66, 68%), other co-morbidities including cancer, sleep apnea, or epilepsy (n=66, 68%) and hypertension (n=43, 44%).

As expected, age was significantly related to primary outcome variables (SF-36PF and performance-based PF, including PPT, UpGo, 6MWT), as well as %Fat and MQ (Table 4.2a). Total number of medical conditions was significantly correlated with primary outcome variables (SF-36PF and performance-based PF, including PPT, UpGo,

6MWT), as well as MQ. Therefore, age and medical conditions were subsequently controlled for in all of the following analyses. Neither age nor medical conditions were correlated with PA.

#### *Relations Between Physiological and Behavioral Variable and Physical Function*

Controlling for age and medical conditions, the primary outcome variables (SF-36PF and performance-based PF measures) were significantly related (Table 4.2b). An inverse relationship existed between SF-36PF and UpGo time ( $r = -0.41$ ,  $p < 0.01$ ), and a positive relationship existed between SF-36PF and PPT, CHR, and 6MWT ( $r = 0.41$ ,  $r = 0.34$ ,  $r = 0.52$ , all  $p < 0.01$ , respectively).

Controlling for age and medical conditions, PA was significantly related to SF-36PF ( $r = 0.33$ ,  $p < 0.01$ ). With regard to performance-based PF measures, PA was significantly related to all assessments [UpGo, PPT, CHR, and 6MWT ( $r = -0.28$ ,  $r = 0.28$ ,  $r = 0.31$ ,  $r = 0.39$ , all  $p < 0.01$ , respectively)]. Partial correlations controlling for age and medical conditions revealed significant relationships between %Fat and SF-36PF ( $r = -0.31$ ,  $p < 0.01$ ) and MQ and SF-36PF ( $r = 0.26$ ,  $p = 0.01$ ).

Results comparing PA across SF-36PF groups [low ( $\leq 65$ ), moderate (66-85), or high ( $>85$ )] are shown in Figure 4.1. Controlling for age and medical conditions, statistical differences were found across low to high SF-36PF groups, with those individuals self-reporting as high functioning reporting statistically greater amounts of moderate PA. Results comparing %Fat across SF-36PF groups [low ( $\leq 65$ ), moderate (66-85), or high ( $>85$ )] are shown in Figure 4.2. Controlling for age and medical conditions, statistical differences were found across low to high SF-36PF groups and moderate to high SF-36PF groups, with those individuals self-reporting as high

functioning having the lowest %Fat. Results comparing MQ across SF-36PF groups [low ( $\leq 65$ ), moderate (66-85), or high ( $>85$ )] are shown in Figure 4.3. Controlling for age and medical conditions, statistical differences were found across low to high SF-36PF groups and moderate to high SF-36PF groups, with those individuals self-reporting as high functioning having the highest MQ.

#### *Independent Predictors of Physical Function*

The independent contribution of PA, %Fat, and MQ on perceived PF (SF-36PF) and performance-based PF (PPT) were evaluated by multivariate regression models (Table 4.3). Age, medical conditions, PA, %Fat, and MQ were independent predictors of perceived PF, explaining 37.7% of the total variance; whereas, MQ and PA were the only independent predictors of performance-based PF, explaining 30.9% of the total variance.

#### **4.4 Discussion**

The study investigated the relationships between perceived and performance-based PF in older women. Additionally, the study explored the influences of physiological and behavioral variables, including PA, %Fat, and MQ, on perceptions of physical function and performance-based PF. The current data support previous findings reporting a moderate relationship between perceived and performance-based PF (1-4). Perception of PF was significantly related to behavioral and physiological variables, including PA, %Fat, and MQ. To our knowledge, this is one of the first studies to explore the relationships among physiological and behavioral variables, and perceptions of PF in older women. Although significant, these relationships were less robust when

compared to the association between perceived (SF-36PF) and performance-based PF (PPT, UpGo, CHR, 6MWT).

Previous studies have shown that older adults with higher performance-based PF engage in greater amounts of PA (27), have lower %Fat (28), and have greater MQ (13). The current study aimed to compare PA, %Fat, and MQ across perceptual levels of PF in older women, a novel approach to understanding the relationships among perception of PF and physiological and behavioral variables. It was hypothesized that older women with higher levels of perceived PF would engage in greater amounts of PA, have lower %Fat, and higher MQ. Our hypotheses were supported in that women with the highest perceptions of physical function reported in engaging in greater amounts of moderate PA, in comparison to the women with lowest perceptions of physical function. When comparing %Fat and MQ across groups, the same pattern emerged with those older women reporting high perceived PF having statistically lower %Fat and higher MQ as compared to the low and moderate perceptual PF groups.

To explore the independent physiological and behavioral predictors of perceived and performance-based PF, multivariate regressions were performed. While the contribution of PA, %Fat, and MQ have been explored in relation to performance-based PF, this study is the first to attempt to determine how the variables independently predict perceived PF in older women. Our findings indicate that each variable in the model (age, medical conditions, PA, %Fat, and MQ) independently contributes to perception of PF in older women. Contrary to our hypothesis, MQ and %Fat were the only variables that independently predicted performance-based PF in our sample. This finding supports previous work indicating that MQ is a significant predictor of PF in older adults (13, 29,

30). The current study also supports previous research reporting the role of adiposity on PF in older adults (9, 12). Although not assessed in the current study, previous research indicates that muscle strength also significantly contributes to performance-based PF (12).

Although the current study utilizes a novel approach to understanding the relationships between physiological and behavioral variables to perceptions of PF in older women, the study is not without limitations. While the sample population is representative of the general population of older women, with regards to medical conditions and obesity, the majority of subjects were community-dwelling and relatively independent functionally. Our study did not include an objective measure of PA, such as accelerometry, which may have increased the sensitivity of the measurement. Finally, although commonly used in the literature, muscle strength via dynamometer was not obtained. Future work should include comparative measures of muscle strength for exploration of the relation with perceptions of PF.

In conclusion, the current study elucidates the significant associations of physiological and behavioral variables to perceived PF in older women. This appears to be one of the first studies employing an interdisciplinary approach to understanding this complex relationship between objective measures of physical function and perceptions of physical ability in older women. Due to the significant yet weak to moderate correlations between perceived and performance-based PF assessments, the study supports previous research indicating that the measures contain concurrent validity, yet may evaluate different dimensions of PF (7). Therefore, it is recommended that both perceived and performance-based PF be assessed when testing the functionality of older adults.

Additionally, more research is needed to better understand specific factors that mediate these relationships, as this information could be used to design behavioral and physical activity interventions that preserve physical function in older adults.

## 4.5 References

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**Table 4.1** Participant characteristics

Characteristics (n = 97)	Range	Mean $\pm$ SD
Age (years)	65 - 89	73.8 $\pm$ 5.6
Height (meters)	1.5 - 1.9	1.7 $\pm$ 0.1
Weight (kilograms)	38.5 - 106.5	69.2 $\pm$ 12.8
BMI (kg/m <sup>2</sup> )	16.1 - 45.3	26.6 $\pm$ 4.7
Total Medical Conditions <sup>a</sup>	0 - 6	2.1 $\pm$ 1.2
Moderate MET-Hrs <sup>†</sup>	0 - 88.2	22.9 $\pm$ 20.9
Adiposity (%Fat)	21 - 55.8	41.6 $\pm$ 6.8
Leg power (watts)	73.6 - 333.1	184.1 $\pm$ 5.9
Muscle quality (watts/kg)	4.2 - 16.2	9.1 $\pm$ 2.8
CHR <sup>c</sup>	0 - 23	12.3 $\pm$ 4.4
Up Go (seconds) <sup>d</sup>	3.3 - 12.6	7.0 $\pm$ 1.6
PPT total score <sup>e</sup>	22 - 36	32.1 $\pm$ 3.1
6MWT (meters) <sup>f</sup>	243.2 - 735.6	484.3 $\pm$ 88.0
SF36-PF <sup>g</sup>	30 - 100	75.4 $\pm$ 18.5

<sup>a</sup>Total self-report medical conditions including cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease, other conditions (sleep apnea, cancer, epilepsy); <sup>b</sup>Community Healthy Activities Model Program for Seniors; <sup>c</sup>30 second chair rise; <sup>d</sup>8 foot up-and-go; <sup>e</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function); <sup>f</sup>6 minute walk test; <sup>g</sup>Short-form-36 Physical function scale (scores range from 0 to 100, with higher scores representing the absence of perceived physical function limitations).

<sup>†</sup> n = 96

**Table 4.2a** Correlations between age, medical conditions, and outcome variables, (n = 97)

	Total Medical Conditions <sup>a</sup>	Moderate MET-Hrs <sup>†</sup>	Adiposity (%Fat)	Leg Power (watts)	Muscle quality (watts/kg)	CHR <sup>c</sup>	Up Go (seconds) <sup>d</sup>	PPT total score <sup>e</sup>	6MWT (meters) <sup>f</sup>	SF36-PF <sup>g</sup>
Age (years)	0.20	-0.04	-0.29**	-0.51**	-0.49**	-0.12	0.43**	-0.36**	-0.45**	-0.30**
Total Medical Conditions <sup>a</sup>		-0.18	0.14	-0.29**	-0.28**	-0.13	0.26*	-0.22*	-0.27**	-0.41**
Moderate MET-Hrs <sup>†</sup>			-0.28**	0.30**	0.27*	0.33**	-0.29**	0.29**	0.39**	0.36**
Adiposity (%Fat)				0.05	-0.05	-0.35**	0.20	-0.13	-0.27**	-0.24*
Leg Power (watts)					0.92**	0.38**	-0.56**	0.46**	0.58**	0.38**
Muscle quality (watts/kg)						0.48**	-0.61**	0.54*	0.58**	0.41**
CHR <sup>c</sup>							-0.59**	0.69**	0.51**	0.37**
Up Go (seconds) <sup>d</sup>								-0.69**	-0.77**	-0.51**
PPT total score <sup>e</sup>									0.66**	0.49**
6MWT (meters) <sup>f</sup>										0.60**

\* Significant correlation at  $p < 0.05$ ; \*\* Significant correlation at  $p < 0.01$ ; <sup>†</sup>n = 96

<sup>a</sup>Total self-report medical conditions including cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease, other conditions (sleep apnea, cancer, epilepsy); <sup>b</sup>Community Healthy Activities Model Program for Seniors; <sup>c</sup>30 second chair rise; <sup>d</sup>8 foot up-and-go; <sup>e</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function); <sup>f</sup>6 minute walk test; <sup>g</sup>Short-form-36 Physical function scale (scores range from 0 to 100, with higher scores representing the absence of perceived physical function limitations).

**Table 4.2b** Partial correlations between physical activity, adiposity, muscle quality, and physical function, (n = 97)

	Adiposity (%Fat)	Leg Power (watts)	Muscle quality (watts/kg)	CHR <sup>b</sup>	Up Go (seconds) <sup>c</sup>	PPT total score <sup>d</sup>	6MWT (meters) <sup>e</sup>	SF36-PF <sup>f</sup>
Moderate MET-Hrs <sup>†</sup>	-0.27**	0.30**	0.26*	0.31**	-0.28**	0.28**	0.39**	0.33**
Adiposity (%Fat)		-0.08	-0.19	-0.39**	0.35**	-0.24*	-0.44**	-0.31**
Leg Power (watts)			0.89**	0.36**	-0.42**	0.32**	0.43**	0.21*
Muscle quality (watts/kg)				0.48**	-0.48**	0.43**	0.44**	0.26*
CHR <sup>b</sup>					-0.60**	0.69**	0.50**	0.34**
Up Go (seconds) <sup>c</sup>						-0.63**	-0.70**	-0.41**
PPT total score <sup>d</sup>							0.59**	0.41**
6MWT (meters) <sup>e</sup>								0.52**

All correlations controlled for age and total number of medical conditions.

\* Significant correlation at  $p < 0.05$ ; \*\* Significant correlation at  $p < 0.01$ ; †n = 96

<sup>a</sup>Community Healthy Activities Model Program for Seniors; <sup>b</sup>30 second chair rise; <sup>c</sup>8 foot up-and-go; <sup>d</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function); <sup>e</sup>6 minute walk test; <sup>f</sup>Short-form-36 Physical function scale (scores range from 0 to 100, with higher scores representing the absence of perceived physical function limitations).

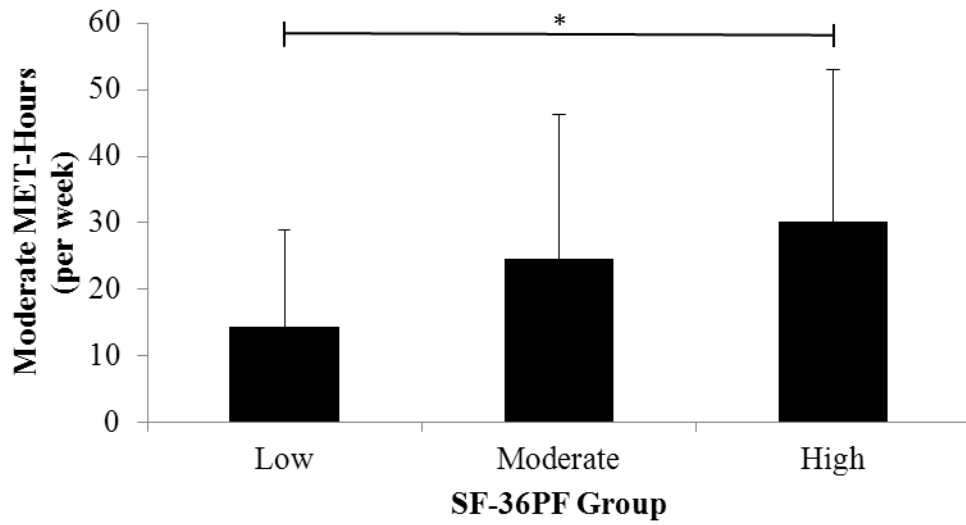
**Table 4.3** Multivariate regression analyses of independent predictors of physical function, (n=96)

Dependent Variable	Variables	Unadjusted Standardized $\beta$	Adjusted Standardized $\beta^*$	P Value
SF-36PF <sup>a</sup>	Age	-0.295	-0.190	0.071
	MC	0.432	-0.280	0.002
	PA	0.358	0.196	0.032
	%Fat	-0.240	-0.195	0.040
	MQ	0.423	0.194	0.060
	Model R <sup>2</sup>		0.377	
PPT <sup>b</sup>	Age	-0.365		
	MC	-0.208		
	PA	0.290	0.159	0.078
	%Fat	-0.130		
	MQ	0.534	0.492	< 0.01
	Model R <sup>2</sup>		0.309	

Multivariate regression model with forward purposeful selection; Alpha set at 0.10.

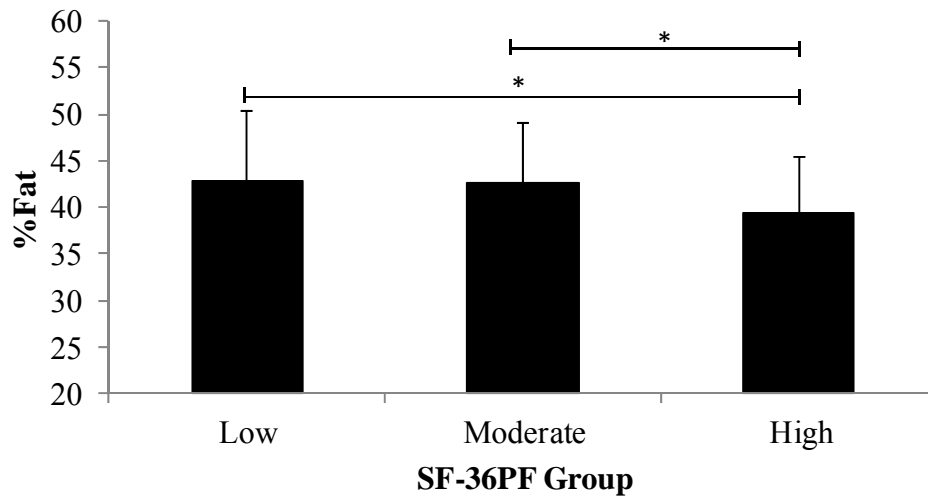
\*Only variables retained in the final prediction model included .

<sup>a</sup>Short-form-36 Physical function scale (scores range from 0 to 100, with higher scores representing the absence of perceived physical function limitations). <sup>b</sup>Physical performance test score (scores range from 0 to 36, with higher scores indicating higher levels of physical function).



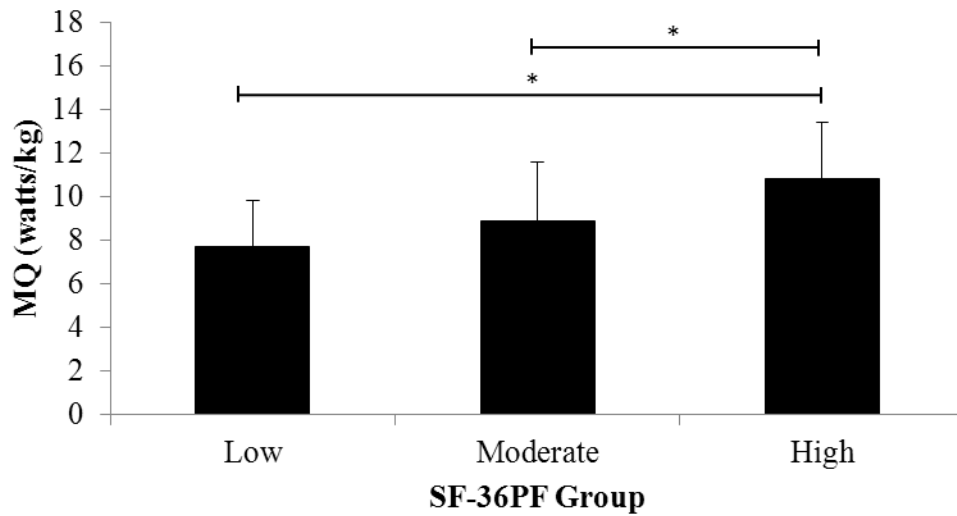
**Figure 4.1.** Mean moderate MET-Hours (per week) values across SF-36PF groups low [ $\leq 65$ ], moderate (66-85), or high ( $> 86$ ). Values are means  $\pm$  SD; controlled for age and medical conditions.

\*  $p < 0.05$  represents statistical differences in group means.



**Figure 4.2.** Mean %Fat values across SF-36PF groups low [ $\leq 65$ ], moderate (66-85), or high ( $> 86$ ). Values are means  $\pm$  SD; controlled for age and medical conditions.

\*  $p < 0.05$  represents statistical differences in group means.



**Figure 4.3.** Mean muscle quality (watts/lower body lean mass) values across SF-36PF groups low [ $\leq 65$ ], moderate (66-85), or high ( $> 86$ ). Values are means  $\pm$  SD; controlled for age and medical conditions.  
 \*  $p < 0.05$  represents statistical differences in group means.

## **CHAPTER 5**

### **SUMMARY AND CONCLUSIONS**

The results from the present study add to the growing body of literature aimed at identifying the most salient predictors of physical function in older women. Physical function is of high importance as it is linked to independence in living and quality of life for older adults. Importantly, older females are at greater risk for obesity, functional decline and physical disability compared to their male counterparts. Our aging society, especially the “baby boomer” segment, combined with the increasing prevalence of obesity and sarcopenic obesity in this population are expected to have major public health implications due to the resultant increased functional declines and physical disabilities. In addition to greatly impacting quality of life, this socio-demographic trend will greatly strain our health care system. Acquiring a more complete understanding of factors that impact physical function in older women could potentially attenuate this increasing public health problem by affording the design of more efficacious interventions.

Recently, muscle power, a capacity measure, has been found to be strongly associated with physical function in older adults. Furthermore, muscle quality (muscle strength per unit of lean mass) has emerged as a potential determinant of physical function. Results from the current study highlight the utility of a novel approach to defining muscle quality combining these two contemporary working paradigms regarding muscle function and physical performance. The present study defined muscle quality as

leg power per unit of lower body lean mass and found this measure to be both correlated with physical function and have the ability to discriminate among levels of performance-based physical function in older women. Future research should continue to investigate this expression of muscle quality in more diverse populations of older adults, including men. Moreover, research investigating the relative associations among muscle quality, defined using power or various strength measures, should be explored toward the end of designing the most effective interventions to reduce risk for physical disability.

One novel aspect of the current study is that it also utilized an interdisciplinary approach to understanding the relationship between perceived and performance-based physical function in older women. Despite much research focusing on physical function and older adults, there is a lack of studies integrating the physiological, behavioral and perceptions of physical function with the objective performance measures of physical function. The current study found that perceptions of physical function in women were significantly related to both adiposity and muscle quality, with women reporting higher perceptions of physical function having lower adiposity and higher muscle quality. Additionally, it was determined that age, medical conditions, physical activity, and adiposity were all independent predictors of perceived physical function, explaining 37% of the total variance. Perceived physical function was also significantly related to performance-based physical function. Based on these findings, future work should not only focus on decreasing adiposity and maintaining or increasing muscle quality, but on increasing perceptions of physical function in older women as this may have positive impacts on performance-based physical function.

Results from this cross-sectional study are projected to inform physical activity and behavioral interventions in older adults in order to develop the most efficacious interventions to preserve physical function. Understanding the integrated relationships among adiposity, muscle quality, and perceived and performance-based physical function in older women will allow for better informed interventions to preserve physical functional independence and help maintain quality of life in older age.