THE INFLUENCE OF BODY MASS INDEX ON SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

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THE INFLUENCE OF BODY MASS INDEX ON SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION IN ADULT WOMEN

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University of Pittsburgh, 2009

Obesity has a negative impact on physical function; however, little is known about limitations in physical function across BMI categories using both self-report and performance-based measures. Furthermore, the impact of BMI on the measurement of function has not been explored. **PURPOSE:** To assess physical function in adult women across BMI categories using self-report and performance-based measures and determine the influence of BMI on the relation of self-report and performance-based measures. **METHODS:** 50 sedentary females (10 in each BMI category: normal weight, overweight, and class 1, 2, and 3 obese) aged 51.2 ± 5.4 years participated. Assessments included demographics, past medical history, physical activity level, BMI, waist circumference, body composition, and self-report and performance-based measures of physical function. Correlation coefficients were computed between BMI and the measures of physical function. Physical function was compared between BMI categories using analysis of variance. The influence of BMI on the relation of self-report and performance-based measures was analyzed by computing correlation coefficients between the measures for the non-obese and obese and by using linear regression. Furthermore, questions from the self-report measure were compared to similar tasks on the performance-based measure for the non-obese and the obese. **RESULTS:** As BMI increased, physical function decreased on self-report and performance-based measures (all $p < .01$). Compared to those that were normal weight and overweight, the obese had poorer physical function on both types of measures (all $p < .01$). A large percentage of participants in the obese groups reported changes in how or how often they performed functional activities. While the performance-based and self-report measures of function were moderately correlated in the sample ($p < .001$), the association between the measures was significantly stronger for the non-obese compared to the obese. Compared to the non-obese, a greater number of individuals with obesity performed differently on walking tests compared to their report. **CONCLUSIONS:** High BMI had an adverse effect on common every-day functional tasks in adult women. Compared to those that are normal weight and overweight, individuals with obesity had the greatest impairments in physical function and tended to less accurately depict physical function abilities.

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PREFACE

I would like to express my gratitude to the members of my dissertation committee for contributing their time and expertise. First, I would like to recognize Dr. John Jakicic, my dissertation director and advisor, for his support and guidance throughout this research project. Your enthusiasm for my ideas was the impetus that propelled this project forward. In addition, I would like to thank Dr. Amy Otto for her suggestions and expert contributions in the area of obesity.

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Finally, I dedicate this dissertation to my family, my husband Paul, and sons Max and (soon to be) Alex. Simply put, words cannot express the joy and love that you have brought to my life.

1.0 INTRODUCTION

Obesity is a major public health problem in the United States and around the world. There has been a substantial increase in the prevalence of obesity globally, even in developing countries [1]. In the United States (US), it is estimated that over 65% of adults are overweight, defined as a body mass index (BMI) greater than 25.0 kg/m^2, with over 30% considered obese (BMI $\geq$ 30 kg/m^2). Despite increased attention to this epidemic, the prevalence of obesity continues to rise [2, 3]. This is of great concern because the health and economic burdens of obesity are vast. Numerous chronic diseases are strongly associated with excess body weight including hypertension, cardiovascular disease, type 2 diabetes, osteoarthritis, and certain forms of cancer [4, 5]. In 2000, the total annual cost of obesity for the US was estimated to be $117 billion [6]. For these reasons, it is imperative that health care professionals are able to effectively evaluate and treat conditions related to overweight and obesity.

Obesity has been shown to have a negative impact on physical function [7-16]. In cross-sectional studies, high BMI is associated with impaired functional mobility and decreased ability to perform activities of daily living. Mobility tasks most often affected include: walking, stair climbing, rising from a chair, activities at floor level, and balancing [9, 12, 17]. Longitudinal studies support the association between mobility limitation and obesity and have shown that excess weight is predictive of future disability [14, 18]. Recent analysis of data from national surveys suggests the prevalence of obesity-related disability is on the rise which reinforces the need for strategies to address this public health concern [18].

Despite substantial evidence relating obesity to impaired physical function, there are several limitations in the current body of research. The majority of studies investigating the relationship between BMI and physical function have focused on individuals with morbid obesity. Thus, little is known about the impact of BMI on physical function across the broader continuum of weight ranges. In addition, most studies have relied on self-report measures to assess physical function. Self-report measures may be subject to personal bias and traditional measures were not designed to capture deficits across a spectrum of functional abilities because they typically only assess whether an individual is able to perform a task or not [19]. There are a few studies that have examined physical function utilizing performance-based measures; however, standard protocols to assess the impairments were not employed.

Previous investigations comparing self-report and performance-based measures of function have shown only moderate correlations suggesting that each assesses a different construct of physical function [19]. Specifically, self-report is an assessment of what an individual perceives they can do and the performance-based measure is an assessment of actual ability [19]. There is the suggestion in previous research that compared to those that accurately report their function, women who under-report ability are more likely to be overweight [20]. However, the association between perception of function and ability in those with excess weight has not been explored. Figure 1 illustrates the conceptual model detailing the association between body mass index, physical function, perception and ability.

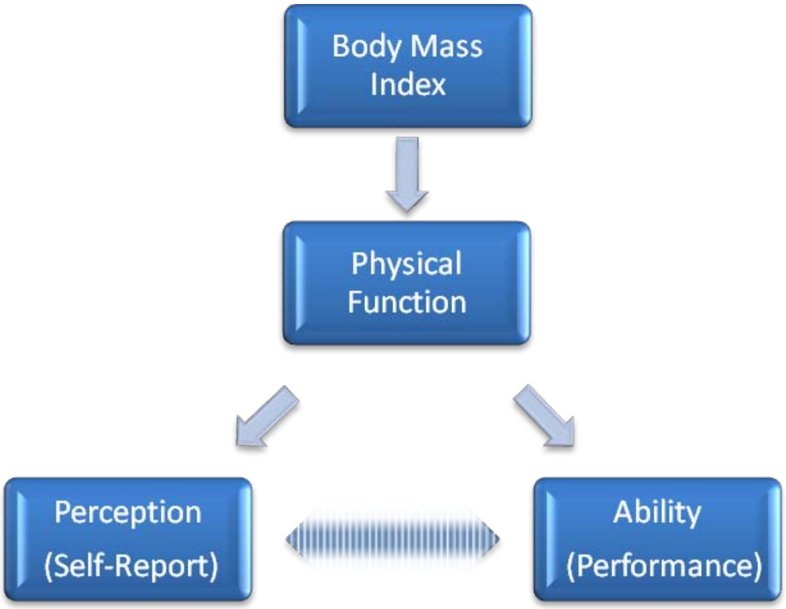


Figure 1 Conceptual Model of Body Mass Index, Physical Function, Perception, and Ability

1.1 STATEMENT OF THE PROBLEM

Research supports the risk of mobility disability in adults that are overweight and obese; however, little is known about limitations in physical function across the spectrum of BMI categories using both self-report and performance-based measures to capture deficits associated with excess weight. Furthermore, the impact of BMI on the measurement of function has not been explored. Because most investigations have relied on self-report of function in obese individuals, this information is critical in accurately determining how BMI impacts physical function.

The purpose of this study was to assess physical function in adults across the range of BMI categories using self-report and performance-based measures. In addition, the impact of body weight on the relation of self-report and performance-based measures of physical function was explored.

1.2 SPECIFIC AIMS AND HYPOTHESES

1.2.1 Primary Aims:

1. To examine the association between BMI and self-report measures of physical function in adults.
2. To examine the association between BMI and performance-based measures of physical function in adults.

1.2.2 Primary Hypotheses:

1. BMI will be negatively correlated with physical function. As BMI increases, physical function, as determined by self-report, will decrease.
2. BMI will be negatively correlated with performance-based measures of physical function. As BMI increases, physical function, as determined by performance-based measures, will decrease.

1.2.3 Exploratory Aims:

1. To examine the difference in self-report measures of physical function between

BMI categories (normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class 1 (30-34.9 kg/m^2), obese class 2 (35.0-39.9 kg/m^2), and obese class 3 ($\geq$40 kg/m^2).

2. To examine the differences in performance-based measures of physical function between BMI categories: normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class 1 (30-34.9 kg/m^2), obese class 2 (35.0-39.9 kg/m^2), and obese class 3 ($\geq$ 40 kg/m^2).
3. To examine the correlation between self-report and performance-based measures of function in adults.
4. To examine if BMI influences the relationship between self-report and performance-based measures of physical function in adults.

1.2.4 Exploratory Hypotheses:

1. There will be gradient effect of BMI on physical function with individuals with class 3 obesity reporting the most limitation in function, followed in descending order by individuals with class 2 obesity, class 1 obesity, overweight, and normal weight adults.
2. There will be gradient effect of BMI on physical function with individuals with class 3 obesity displaying the most limitation in physical function, followed in descending order by individuals with class 2 obesity, class 1 obesity, overweight, and normal weight adults.
3. Self-report and performance-based measures of physical function will be moderately correlated based on correlation coefficients computed between the quantitative self-report measure and the performance-based tests.
4. Body mass index will influence the relation of self-report with performance-based

measures of physical function. Specifically, as BMI increases, the correlation between self-report and performance-based measures of physical function will decrease. In addition, compared to those with a BMI < 30, a greater percentage of individuals with obesity will inaccurately report their ability.

2.0 REVIEW OF THE LITERATURE

2.1 PREVALENCE OF OVERWEIGHT AND OBESITY

Obesity is a major public health problem both in the United States and globally with increasing prevalence in all age groups over the past 25 years. It is estimated that 65% of adults in the United States are overweight or obese and the prevalence of overweight in children and adolescents, and obesity in adults, continues to rise [2, 3]. Most recent national surveys estimate that 32.2% of adults are obese (BMI $\geq$ 30 kg/m^2) and 17% of children and adolescents are overweight (BMI for age at 95th percentile or higher) [21]. Men and women of middle age (40-59 years) have the highest rates of obesity (40% and 41% respectively) compared to other age groups. In females, there are large ethnic disparities in prevalence of obesity with Mexican-American and black women having higher rates of obesity compared to non-Hispanic whites; however, these ethnic disparities are not observed in men [21].

2.2 MEASUREMENT OF OVERWEIGHT AND OBESITY

Body mass index (BMI) is the most common tool to assess level of adiposity in adult males and females. BMI has been shown to be a reliable indicator of level of adiposity when compared to direct measurement of body fat [22]. The BMI is calculated by dividing an individual's weight in kilograms by their height in meters squared (kg/m^2). Using the BMI, individuals are classified as underweight (< 18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), obese class 1 (30-34.9 kg/m^2), obese class 2 (35-39.9 kg/m^2), and obese class 3 ($\geq$ 40 kg/m^2). The above categories of BMI were developed based on associated health risks [23].

There are several limitations to the use of BMI exclusively as a measure of adiposity. BMI has the tendency to overestimate body fat in individuals with high muscle content. In addition, BMI may also underestimate body fat for older individuals that have lost muscle mass [24]. For these reasons, the BMI may be used in conjunction with measurement of waist circumference, which estimates regional adiposity, and the composite results may provide a more accurate assessment of health risk (see Table 1).

Table 1 Disease Risk Relative to Normal Weight and Waist Circumference

	BMI (kg/m^2)	**Disease Risk Relative to Normal Weight and Waist Circumference**	
		Men: < 102 cm **Women: < 88 cm**	**Men: >102 cm** **Women: > 88 cm**
Underweight	< 18.5	----	----
Normal	18.5-24.9	----	----
Overweight	25-29.9	Increased	High
Obesity			
Class I	30-34.9	High	Very high
Class II	35-39.9	Very high	Very high
Class III	$\geq$ 40	Extremely high	Extremely high

Source: National Heart, Lung and Blood Institute

2.3 PUBLIC HEALTH IMPLICATIONS OF OVERWEIGHT AND OBESITY

2.3.1 Mortality

Epidemiological studies have found that increased BMI is associated with higher mortality rates and that the risk is curvilinear with those at the highest level of obesity having the lowest rates of survival, and those at a BMI of 22 kg/m^2 having optimal rates of survival [25-28]. A large prospective cohort study of adults 50-71 years of age found 20-50% higher risk of mortality for the overweight and a 2-3 times increased risk of mortality for those that were obese [28]. Data from the National Health and Nutrition Examination Survey (NHANES) have shown the most common causes of death in those that are overweight and obese were diabetes, cardiovascular disease, and certain forms of cancer [29].

2.3.2 Chronic Diseases

High BMI is associated with increased risk chronic diseases such as cardiovascular disease (CVD), type 2 diabetes, and osteoarthritis. In a large prospective study of more than 1 million US adults, higher BMI was most predictive of death from cardiovascular disease. Significant increases in risk were evident for men with BMI greater than 26.5 kg/m^2 and women with a BMI greater than 25.0 kg/m^2 [26]. In the Nurses' Health Study, BMI was most strongly related to deaths from cardiovascular disease compared to other causes. Women with a BMI of 32 kg/m^2 or greater had a relative risk of cardiovascular death of 4.1 compared to those with a BMI of less than 19 kg/m^2 [30]. Furthermore, data from the Framingham Heart Study suggest that risk factors for cardiovascular disease increase in conjunction with increasing BMI even within the normal BMI weight range [31].

Multiple prospective studies have shown that higher BMI is strongly associated with increased risk of type 2 diabetes. In the Nurses' Health Study, higher BMI was the predominant risk factor for diabetes and risk increased as body mass increased [32]. Compared to women whose weight remained relatively stable over the 18 years, those that gained 5.0-7.9 kg of body weight had a relative risk of 1.9 (CI, 1.5 – 2.3), those that gained 8.0-10.9 kg had a relative risk of 2.7 (CI, 2.1- 3.3), and those that gained 20 kg or more had a relative risk of 12.3 (CI, 10.9-13.8) [32]. In the US Males Health Professionals Study, BMI significantly increased risk of diabetes, even within the normal weight range. Moreover, compared to men with a BMI of 23 kg/m^2 or less, men with a BMI greater than 35 kg/m^2 had significantly higher relative risk of type 2 diabetes (RR = 42.1, CI, 22.0-80.6) [33].

Obesity is also linked to increased prevalence of chronic musculoskeletal disorders such as osteoarthritis [34, 35]. Research has shown that obese individuals suffer more from musculoskeletal problems than normal weight individuals [10, 36]. There is evidence that obese individuals have increased incidence of knee pain and arthritis [10, 37, 38], hip arthritis [10], foot and heel pain [10, 39] and low back pain [40, 41] compared to those of normal weight. Of these disorders, knee osteoarthritis associated with excess weight has received the most attention [42], most likely because there are data suggesting high pressure loads on the knee may contribute to joint deterioration and this association has been demonstrated in longitudinal studies [34, 38, 43-45]. It is estimated that 24% of knee OA is attributable to obesity [46].

2.3.3 Disability, Home-bound Status, and Nursing Home Admission

Several longitudinal and cross-sectional studies support that obese individuals are not only at risk for future disease, but also at risk for future disability [14, 15, 17, 47-50]. Analysis of data from the epidemiological follow-up study of the National Health and Nutrition Examination Survey (NHANES) I (1971-1987) has shown that higher BMI is predictive of mobility disability in middle-aged and older women [14]. After adjusting for age, socioeconomic status, and smoking, individuals in the young–old (45-59 years) group with a BMI greater than 27 and individuals in the old-old (60-74 years) group with a BMI greater than 28.1, had a two-fold increase in risk of disability compared to those in lower BMI categories.

A systematic review of trends in disability among US adults reveals improvements in measures of old age disability [51]. Despite this overall trend, there is evidence that disability among individuals with obesity is on the rise. Alley and Chang examined prevalence of functional impairment from two waves of the NHANES (NHANES 1988-1994 and NHANES 1999-2004) to identify disability trends in obese older adults. They found that those in the later survey were more likely to report functional impairment, an increase of 5.4% between the two surveys, suggesting that the risk of disability associated with obesity, is increasing [18]. The growth in disability could not be attributed to the increased prevalence of morbid obesity and was in contrast to an overall trend on decreased levels of disability in the non-obese. The largest increase in functional impairment was in walking ¼ of a mile [18]. Lakdawalla et al examined data from a nationally representative sample to determine disability trends in adults aged 18-69 years. They found an increase in disability rates for individuals 30-59 years of age. Though the mechanisms responsible for the emerging growth of disability in younger adults were not able to be determined based on this analysis, the authors speculate that obesity may represent one plausible explanation [52].

Given the association between excess weight and disability, it is not surprising that obesity is also linked to higher rates of home-bound status and nursing home admission. In a study of 21,645 community dwelling men and women, obesity was found to be an independent risk factor for self-reported home-bound status, even after controlling for age, income and functional limitations [53]. Obesity appears to exert an influence on late-life disposition at an early age. In a study by Elkins et al, individuals that were obese at midlife were 30% more likely than normal weight adults to be admitted to a nursing home later in life. This relationship was found after adjusting for other health factors, age, and gender. [54]. Having obesity at an older age has also been shown to increase risk of nursing home admission. In a study by Valiyeva et al, individuals aged 65-75 years who were obese had a relative risk of nursing home admission of 1.3 compared to those who were not obese ($p < .05$) [55]. It is predicted that nursing home admissions will grow 10-25% if current obesity trends continue [52].

Increased prevalence of disability associated with obesity presents great concern because disability is associated with increased risk of mortality [56, 57], exorbitant health care costs [56, 58] and decreased health-related quality of life [59-61]. Disabled obese individuals place an enormous strain on health care resources because effective care often requires extensively trained staff, specialized equipment, and environmental modifications [62].

2.3.4 Economic Burden of Obesity

The economic consequences of obesity and its associated health conditions are enormous. An early investigation of US health care expenditures related to obesity was conducted by Wolf and

Colditz in 1998 using a prevalence-based approach [63]. Costs were estimated in 1995 dollars. Total health care costs related to obesity were approximately $51.6 billion in direct costs and $47.6 billion in indirect costs, totaling $99.2 billion. Coronary heart disease, type 2 diabetes and musculoskeletal disease associated with obesity were the three largest contributors to this burden [63].

Obesity exerts its influence on health care expenditures in a large-part due to the impact on indirect costs. Individuals with obesity have been shown to have more work restrictions due to pain compared to those of normal weight [41]. There is also evidence that those with obesity have more disability and work-related injuries than those with lower body mass indexes [64] as well as reduced productivity while on the job [65]. In the Swedish Obese Study, individuals that were obese had 1.4 to 2.4 times sick leave compared to those of normal weight and were more likely to utilize disability pension [66].

Health expenditures in the obese can also be attributed to increased direct medical costs. Obese individuals have a greater number of physician visits [67] and are more likely to receive prescription medications than those of normal weight [66, 68, 69]. Studies also show that those with excess weight are also more prone to injuries such as sprains, strains, and joint dislocations [70]. Furthermore, obese individuals are much more likely to have surgical procedures, such as total joint replacement, compared to non-obese individuals [71] contributing to higher health expenditures for the obese.

2.4 THE IMPACT OF OBESITY ON PHYSICAL FUNCTION

Higher BMI is associated with decreased level of physical performance and increased self-report of impairment in physical function in adults. These findings have been supported in cross-sectional and longitudinal studies of middle-aged and older adults. Research has shown that limitations in function are related to body composition with excess fat mass associated with future disability as well as decreased level of physical function measured by self-report and performance-based measures. Furthermore, there is evidence that location of adiposity may influence physical function with central adiposity exerting a more negative impact on self-reported functional abilities.

2.4.1 Self-Reported Limitations in the Obese

Obesity has been shown to have an adverse effect on self-reported physical function. Analysis of data from the epidemiological follow-up study of the National Health and Nutrition Examination Survey (NHANES) I (1971-1987) has shown that high BMI is associated with self-report of incident mobility disability in middle-aged and older women [14]. After adjusting for age, socioeconomic status, and smoking, individuals with a high past BMI had a two-fold increase in risk of disability compared to those in lower BMI categories [14]. Similar findings were noted by Galanos and colleagues who also examined self-reported functional limitations in the NHANES I Follow-Up Study. A gradient effect of BMI on physical function was found with those at the highest ranges of BMI having the greatest risk of functional impairment [13]. The relationship between increasing BMI and increasing self-report of limitation in physical function was also found in a cross-sectional analysis of middle-aged and older women in the Nurses'

Health Study [7]. In this study, women with obesity averaged 9 points lower in physical function score of the SF-36 representing an estimated 10% loss of function compared to those in the normal weight reference group [7].

There appears to be a gender discrepancy in the self-report of functional limitation related to BMI with females more negatively affected by higher BMI [49, 72]. In a cross-sectional study of 7,120 older community dwelling adults, the impact of BMI on self-reported physical function was examined in gender-specific quintiles. For women in the highest quintile, there was a significant increased risk of functional impairment; however, there was no relationship between BMI and self-reported limitations in men [72].

There is also evidence that women with more severe obesity may suffer more than men at similar levels of obesity. In longitudinal cohort study by Jensen and colleagues, both men and women with BMI's greater than 35 kg/m^2 had high risk of reporting functional impairment; however, women with a BMI greater than 40 kg/m^2 were twice as likely to report functional decline compared to men [49]. The mechanisms for the differential impact of body mass index on physical function are unclear but may be related to gender differences in body composition [73], increased willingness of women to report functional limitations, and gender differences in disease burden which may influence physical function [74].

2.4.2 Performance-Based Limitations in the Obese

The adverse effect of higher BMI on physical function is supported in studies utilizing objective, performance-based measures. Evers and Larsson [9] used performance-based measures of physical function to compare the performance of overweight and obese middle-aged adults (n = 57) to normal weight adults (n = 22) on sixteen functional tasks. They found that activities such as rising from low furniture, walking while carrying heavy items, and stair climbing more difficult for overweight and obese females compared to age-matched controls of normal weight [9]. In a larger cross-sectional study of 4,000 older adults aged 65 years and older, Woo and colleagues found that subjects with obesity (BMI $\geq$ 30 kg/m^2) had the poorest walking performance compared to normal and overweight subjects [75].

Limitations in physical function are not limited to tasks involving the lower extremity. Though there are limited data, both upper and lower extremity physical function have been shown to be impaired in those with higher BMI's. In a study of 90 older women, those with higher BMI's had greater difficulty with performance-based upper body tasks such as eating, dressing and writing in addition to walking and stair climbing tasks [17]. Furthermore, in a study of 705 older community-dwelling women, higher BMI was associated with more difficulties in performing activities of daily living, some of which involved upper-extremity use [76].

2.4.3 Review of Body Composition Studies

Research has shown that limitations in physical function are related to body composition with higher fat mass associated with greater levels of disability [12, 77-79]. In cross-sectional study of 1,655 community dwelling men and women, Sternfeld et al examined the relationship between self-report and performance-based measures of function and body composition determined by bioelectrical impedance (BIA). They found that higher fat mass was associated with poorer walking performance and increased likelihood of self-reported functional limitation. In another investigation using data from the Framingham Heart Study, high percent body fat (determined by DEXA) was associated with greater odds of self-reported disability for men (OR = 3.08 (95% CI 1.22-7.81) and women (OR = 2.69 (95% CI 1.45-5.00) [79]. Analysis of data from the Cardiovascular Health Study supports the association between high body fat and mobility disability. In this study, those in the highest tertile of body fat determined by BIA had greater odds of mobility disability (OR = 3.04 (95% CI: 2.18, 4.25) for women and OR = 2.77 (95% CI: 1.82, 4.23) for men) compared to those in the lowest tertile of body fat [78].

2.4.4 Review of Regional Adiposity Studies

A small number of studies have examined the relationship between regional body fat and physical function and have shown a relationship between central adiposity and functional impairment. In a cross-sectional analysis of 9,704 women, Ensrud and colleagues found that a greater waist to hip ratio was associated with self-reported limitation in function [8]. The association between large waist circumference and disability is supported in a cross-sectional study of young and middle aged adults. In this study, Han et al found that large waist circumference was associated with disability affecting basic activities of daily living in men and women aged 20-59 years old. Adults in the highest tertile of waist circumference were more likely to have limitations in walking, stair climbing, bending, kneeling, and stooping compared to those in the lowest tertile. In this study, the adverse impact of central adiposity was more pronounced in women compared to men [47].

2.4.5 Potential Mechanisms for Functional Limitations in the Obese

The mechanisms responsible for decreased levels of function in the overweight and obese are not well-defined. It is hypothesized that limitations in physical function may be associated with direct pathologies, such as chronic diseases, related to excess weight [80-82]. Other mechanisms associated with excess weight that may impact function include decreased muscular strength, altered movement patterns impacting gait [83], and/or pain related to certain activities. The identification of mechanisms responsible for the limitations will aid the development of strategies to prevent future disability in this vulnerable group [84].

2.4.5.1 Decreased Muscular Strength

Research has shown that in general, individuals with obesity have greater absolute isometric and isokinetic muscular strength compared to those of normal weight [85, 86]. However, studies that have adjusted for the increase in fat-free mass associated with obesity by expressing strength relative to body weight, have shown that individuals with obesity have decreased muscle strength in lower extremity musculature compared to those of normal weight [87, 88]. In a study that utilized a more sophisticated allometric approach to adjust for fat-free mass, researchers found a minimum of a 6% reduction in lower extremity strength groups in those with obesity compared to more lean counterparts [85]. Decreased strength, particularly in the lower extremities, has been associated with functional limitations in older adults [89] and may explain in part, the functional limitations observed in those with excess weight.

2.4.5.2 Gait Abnormalities

Obesity has been shown to have a negative effect on gait and locomotion. Most research pertaining the influence of BMI on gait is focused on temporospatial parameters such as cadence, stride length, step width and gait speed. In a study of 34 morbidly obese adults (BMI = 40.1 +/- 6.0 kg/m^2), cadence was found to be decreased compared to normal weight individuals [90]. Obese subjects took 1.4 steps per second compared to normal weight individuals who typically take 1.8 steps per second. This finding is supported by DeVita and colleagues who found that obese individuals had an 11% slower step rate compared to lean adults at a self-selected walking speed [91]. These investigators also found that stride length is decreased in obese compared to those of normal weight [90-92]. DeVita and colleagues interpreted the decrease in stride length as a compensatory mechanism to decrease knee joint torque during walking [91].

Step width, or walking base, is the distance between points of contact of the left and right feet and is increased in obese individuals compared to those of normal weight [90, 92, 93]. It has been speculated that this could be compensatory mechanism to allow for greater stability during gait, or more simply, could be a result of larger fat mass in the thigh area leading to wide base of support [92]. The mechanisms for gait abnormalities in obese individuals are not well understood; however, collectively they are likely to contribute to a decrease in gait velocity, or gait speed.

Gait speed has been used as a clinical tool to predict adverse health-related outcomes in older adults [94]. Usual gait speed has been found to be decreased in obese individuals compared to normal weight adults [90-92]. Spyropoulos and colleagues analyzed kinematic components of gait in 12 obese subjects ranging in age from 30 to 47 years. They found that the obese individuals walked at a significantly slower rate compared to normal weight individuals (1.09 m/sec vs. 1.64 m/sec, $p < .001$) [92]. Similarly, DeVita et al found that obese adults walked 16% slower than lean individuals when asked to self-select walking speed [91]. These findings are supported by de Souza et al who analyzed the gait of 34 obese individuals (BMI 40.1 +/- 6.0 kg/m^2) aged 47.2 +/- 12.9 years and found obese individuals walked at a speed of .73 m/sec. [90]. These findings are concerning because slow gait speed (< 1.0 m/sec) in community-dwelling older adults has been associated with multiple adverse health outcomes including higher rates of lower extremity limitation events, hospitalization and death [94, 95].

2.4.5.3 Pain

Musculoskeletal pain is associated with functional limitation and disability [96]. Several studies have shown that individuals with higher BMI's have more musculoskeletal pain compared to those of normal weight [41, 97, 98]. Hulens et al examined predictors of 6-Minute Walk Test performance in normal weight, overweight and obese individuals and found that those with morbid obesity had more complaints of musculoskeletal pain compared to less obese and normal weight individuals (34.9%, 17.7% and 11.4%, $p < 0.05$). Similar findings were found on a larger scale in the Swedish Obese Subjects (SOS) study. In this study, there was significantly higher prevalence of musculoskeletal pain involving the neck, back, hip, knee and ankle joints in obese males and females ($n = 6,328$) compared to a reference population ($n = 1,135$) (OR ranging from 1.7 for back pain to 9.9 for ankle pain). In this study, pain that restricted work activities was more common in women compared to men in all bodily locations [41].

2.4.6 The Impact of Intentional Weight Loss on Physical Function

Intentional weight loss has been shown to lead to improvement in physical function in adults with obesity with the majority of improvements found in activities such as walking and stair climbing ability [11, 99-101]. Larsson UE studied the impact of a dietary weight loss program on function in 57 obese females aged 20-65 years. After this 3-month diet intervention, subjects lost a significant amount of weight ($\bar{x} = 14.7$ kg, $p < .001$). Weight loss significantly improved performance on a battery of physical performance tests that included walking, rising from the floor, and climbing onto a high stool [11]. In addition, self-report of functional status improved based on responses to disability questionnaires [11].

Perception of physical function, measured in the health-related quality of life physical function subscale ($HRQL_{PF}$) of the Short-Form (SF-36) Health Survey, also has been shown to improve with weight loss [102-105]. Blissmer and colleagues found improvements in $HRQL_{PF}$ after a 6-month diet and exercise intervention. At 24 months, these improvements were maintained, despite partial regain of weight lost. These findings are supported in a study by Kaukua et al who found also found improvement in $HRQL_{PF}$ immediately following a diet and exercise weight loss program that remained two years after the intervention [105]. However, in contrast to these findings, others have found that despite short-term increases in $HRQL_{PF}$ scores with weight loss, improvements were not maintained after one year [103].

Weight loss interventions have been found to have similar effects on physical function in obese individuals with co-morbid conditions. In individuals with knee OA, weight loss has been shown to lead to improvements in walking, stair climbing ability and self-reported function [106-108]. Miller et al compared the impact of weight loss achieved through diet and exercise to a weight-stable control group. A significant improvement in self-reported function, 6-Minute Walk Test distance, and stair climbing ability were found in the weight loss group compared to the weight stable group [108]. In another study of individuals with knee OA, Messier et al sought to determine the independent effects of behavioral therapies on function. Subjects (n = 316) were randomized to control, diet-only, exercise-only and diet plus exercise intervention. Mean weight loss differed between groups with the diet plus exercise group losing the most weight ($\bar{x}$ = 5.7%) and the control group losing the least ($\bar{x}$ = 1.2 %.) Subjects in the exercise plus diet group had the greatest improvement in physical function measured by self-report measures and performance-based tests including the 6-Minute Walk Test and timed stair climb [109].

Improvements in physical function associated with weight loss have also been found in older adults with obesity. Jensen et al enrolled 18 obese women aged $\geq$ 60 years in a 3-month weight loss program consisting of diet and physical activity. In this program, subjects were given a tailored low-calorie diet, provided with pedometers, and instructed to walk a minimum of 5,000 steps per day. Participants lost a significant amount of body weight ($\bar{x}$ = 4.3 kg) and had concomitant improvements in physical performance and self-report functional measures. In another study of older adults ($\bar{x}$ = 70 years), 27 obese individuals were randomized to a weight loss treatment group consisting of diet and exercise or a control group. The diet and exercise intervention consisted of a low-calorie diet plus 90 minutes of supervised exercise sessions 3 times per week for 6 months. Subjects in the treatment group lost an average of 8.2 kg of weight while the control group remained weight stable. Scores on the Physical Performance Test (PPT), walking speed, balance and self-report of function improved in the treatment group ($p < .05$) compared to the controls. These studies suggest that moderate weight loss, achieved through diet and exercise, is a viable means for achieving improvements in physical function in adults and older adults with obesity.

2.5 MEASUREMENT OF PHYSICAL FUNCTION

In order to investigate the disablement process, measures of physical function are employed to differentiate functional capacity between individuals. Physical function measures have been shown to be an effective means in determining treatment outcomes and in predicting adverse health events such as future hospitalization and disability [16, 56, 94, 110]. In a large epidemiological study, measures of physical function were able to discriminate risk of death and nursing home placement in older adults [111]. Even in those without outward signs of disability, functional decline has been predicted based on results of physical function assessment [110].

Physical function can be measured with self-report and/or performance-based measures. Previous investigations comparing self-report and performance-based measures of function have shown weak to moderate correlations suggesting that each may tap into a different dimension of physical function [19, 112]. Specifically, the self-report measure is an assessment of what an individual perceives they can do and the performance-based measure is an assessment of actual ability [19]. Each type of measure has been shown to have distinct advantages and disadvantages.

2.5.1 Performance-Based and Self-Report Measures

Performance-based measures alone, or used in combination with self-report measures, have been shown to predict clinical outcomes better than self-report measures [94]. It has been suggested that traditional self-report measures may not adequately describe detrimental functional changes that occur prior to the onset of disability because most were designed to assess inability to perform a task or “difficulty” in performing a task [113, 114]. Individuals may not recognize subtle declines in physical function and thus, may not accurately report impairments. In a study that compared results of subjective and performance-based measures of function in community-dwelling older women, performance-based measures of physical function were able to identify deficits in function that were not captured by self-report measures [20].

Despite the advantages of performance-based measures, some portend that individuals are more willing to complete self-report measures and that results are easier to interpret [115].

Furthermore, there is evidence that self-report measures designed to distinguish gradations of higher level functional ability with the inclusion of more demanding levels of common activities may predict future disability comparably to performance-based measures [115]. Given the advantages and disadvantages of each type of physical function measure, it is recommended that the most accurate assessment of physical function be obtained utilizing a combination of self-report and performance-based measures [19].

2.5.2 Importance of Measuring Physical Function across BMI Categories

Research supports increased risk of impaired physical function for those with greater BMI's; however, most investigations have relied on self-report of disability and few have utilized performance-based measures to identify functional limitations that may precede the onset of disability. Moreover, no studies were identified that examined the association between perception of physical function and ability in those with excess weight. Thus, it is not currently known how self-report measures relate to performance-based measures across the spectrum of weight ranges. The application of self-report and performance-based measures to normal weight, overweight, and obese adults would yield critical information about the impact of BMI on physical function. First, the magnitude of functional impairments imposed by varying levels of excess weight could be better quantified; second, the relationship between perceived limitations and abilities could be explored; and third, clinically relevant measures of physical function could be identified.

3.0 METHODS

3.1 SUBJECTS

Fifty sedentary females aged 40-60 years were recruited to participate in this cross-sectional study. The primary reason for restricting the sample to this age range and gender was to control for potential confounding variables that may impact function. However, there were several additional reasons for limiting the sample to this age and gender. Studies reveal a gender discrepancy in the impact of obesity on physical function with women more negatively affected by excess body weight compared to men [49, 72, 74, 116]. Furthermore, the prevalence of disability in this age range has increased despite decreases in disability levels in older adults, which is attributed in part to rising levels of obesity [52]. Despite this, few studies have examined physical function in women aged 40-60 years.

To ensure representation across the span of BMI levels, 10 normal weight (BMI between 18.5 and 24.9 kg/m^2), 10 overweight (BMI between 25.0 to 29.9 kg/m^2), 10 class 1 obese (BMI between 30.0 to 34.9 kg/ m^2), 10 class 2 obese (BMI between 35.0-39.9 kg/m^2), and 10 class 3 obese (BMI $\geq$ 40 kg/m^2) individuals were recruited.

Inclusion criteria:

1. 40-60 years of age
2. Female

3. Body mass index 18.5 to > 40 kg/m^2

Exclusion criteria:

1. Report being pregnant or breastfeeding
2. History of orthopedic condition that would significantly compromise physical function independent of obesity including the following conditions: acute musculoskeletal injury such as sprain or strain, rheumatoid arthritis, Paget's disease, bone diseases, previous trauma/surgery leading to disability (i.e. fused joints, amputation) and acute low back pain.
3. History of neurological condition that would affect coordination and/or sensation such as Parkinson's disease, stroke, and multiple sclerosis.
4. Cancer with active treatment
5. Cardiac event such as a heart attack in the past six months
6. Non-elective hospitalization for a life-threatening illness or surgery in the past six months
7. Use of an assistive device for ambulation
8. Presence of any uncontrolled medical condition that would prevent safe participation in the study (Resting systolic blood pressure > 160 mmHg or resting diastolic blood pressure > 90 mmHg, respiratory disease with significant dyspnea at rest, cardiovascular disease with symptoms such as chest pain with activity).
9. Currently participating in regular exercise of at least 20 minutes per day on 3 or more days of the week during the prior 6 months.

Note: Potential subjects with type 2 diabetes, osteoarthritis, sleep apnea, hypertension (controlled), hyperlipidemia, and other conditions associated with obesity were eligible for this study.

3.2 SCREENING AND SAFETY

Subjects were informed of the risks of participating in this research study and asked to sign a written consent to participate. All subjects participated in initial screening procedures including the completion of a physical activity readiness questionnaire (PAR-Q) (Appendix A). Medical clearance was obtained prior to proceeding if a subject had a positive response on the questionnaire.

3.3 RECRUITMENT

To successfully obtain subjects for this study, the following recruitment techniques were utilized: advertisement in local papers, internet sites, and newsletters, targeted mailings, and posting advertisements in targeted areas.

3.4 STUDY PROCEDURES

Anthropometric data (height, weight, waist circumference, and body composition) were collected first, followed by self-report and interview administered questionnaires. Performance-based measures were administered after the self-report measures to minimize the influence of the persons' performance on their self-reporting of function. The performance-based measures were administered in the following sequence: gait speed, Modified Sit to Stand Test, and 6-Minute Walk Test. The 6-Minute Walk Test was administered last to minimize the influence of participant fatigue on subsequent measurements. Data were collected by a licensed physical therapist both in Forbes Tower on the University of Pittsburgh campus and in Birmingham Towers at the University of Pittsburgh Physical Activity and Weight Management Research Center.

3.5 MEASUREMENTS

3.5.1 Weight and Body Mass Index

Body weight was determined using a Tanita Model TBF-310 GS Weight Scale. Subjects wore lightweight clothing and were weighed without shoes. Height was determined through the use of a wall-mounted stadiometer after shoes were removed. The subject's body mass index was computed from the height and weight measurements (kg/m^2) using a calculator. BMI was validated using the Tanita Model TBF-310 GS Weight Scale.

3.5.2 Waist Circumference

Circumference of the waist was measured in centimeters using a Gulick tape measure. The waist circumference was measured at the smallest part of the waistline between the xyphoid process and the umbilicus according to the Anthropometric Standardization Reference Manual (1998). This measurement site has been shown to be more highly correlated with cardiovascular disease risk than was umbilical waist circumference in women [117].

3.5.3 Body Composition

Measurement of body composition to determine lean body mass using bioelectrical impedance analysis (BIA) was performed with a Tanita Model TBF-310 GS Weight and Body Composition Scale. BIA was assessed using standards recommended by the manufacturer.

3.5.4 Self-Report Measures

The Physical Functioning Inventory (PFI) was used as a self-report measure of physical function. This inventory has been used to assess earliest signs of decline in function in healthy adults across a wide range of ages. Inter-rater and test-retest reliability were assessed in the Baltimore Longitudinal Study of Aging and percentage agreement was greater than 80% on each of the tasks assessed. This test was selected because it has been designed to detect pre-clinical changes in function and thus is believed to offer a more sensitive measure of functional impairment then other self-report measures [118]. The measure is unique because it explores if the individual has modified the task or changed the frequency in which they perform the task, both of which are characteristic of early functional decline.

For this study, the categories included from the PFI were the mobility inventory (walking up 10 steps, walking ½ mile, walking 1/3 of a block, walking around the house, and stooping, crouching, or kneeling) and the moderate and strenuous activity inventory. These categories were selected because they coincide with the performance-based measures allowing greater ease for comparison of measures. This measure was used in a qualitative manner to describe limitations in physical function in this sample. The general question sequence for the Physical Functioning Inventory can be found in Appendix B.

The Late Life Function and Disability Instrument (LLFDI) was used as a second self-report measure of physical function. The LLFDI is composed of a 16-item disability component and a 32-item function component. The disability component of the LLFDI is comprised of a frequency and limitation total score. The frequency component score is further divided into a social (9 items) and personal (7 items) participation items. The limitation component score is divided into instrumental (12 items) and management (4 items) scores. The function component of the LLFDLI is comprised of upper extremity (7 items), basic lower extremity (14 items) and advanced lower extremity (11 items) scores. Raw scores for each section were transformed into a scaled score ranging from 0-100 using the LLFDI Scoring Software. Higher scores were representative of higher level of function and lower level of disability. The general question sequence for the LLFDI can be found in Appendix C.

The LLFDI has been shown to have concurrent validity with the physical functioning subscale of the Medical Outcomes Study 36-item Short-Form Health Survey (SF-36) [119] as well as concurrent and predictive validity based on moderate associations with performance-based measures of physical function such as the 400-meter walk and the Short Physical Performance Battery [120].

3.5.5 Performance-Based Measures

Gait speed has been shown to be a quick and inexpensive clinical tool for predicting a number of health related outcomes in older adults including nursing home admission, falls, disability and death [95]. The intraclass correlation coefficient for test-retest reliability in adults and older adults has been shown to be > .90 [121, 122].

Gait speed was determined by recording the time for each subject to walk the central 4 meters of an 8 meter course at usual, self-selected pace using a stopwatch. The initial and final 2 meters were included to allow for acceleration and deceleration. Gait speed was calculated as the distance (4 meter) divided by the time it took to complete the 4 meter walk in seconds. The gait speed was reported in meters per second (m/s). This test was repeated twice for each subject and the average of two trials was used.

Chair stands have been utilized as a performance-based measure of lower body function and have been shown to have good reliability in older adults [123]. Subjects were asked to sit in a hard-backed chair with a seat height of 43 cm from the floor and fold their arms across their chest. The subject was asked stand up keeping arms folded across the chest. If the subject was successful in standing without using arms, they were asked to stand up and sit down as quickly as possible five times in a row, with time measured at the final standing position at the end of the fifth stand. During the test, subjects were asked to sit so that their buttocks rest fully on the chair for the trial to count. In addition, the subjects were asked to obtain full erect posture in between each sit to stand trial. For quality control, the test-retest reliability of this test was determined in a random sub-sample of subjects during the course of the study. Appendix D provides an illustration of this test with instructions for completion.

The 6-Minute Walk Test was used as a performance-based measure of function. This test has been used as a measure of aerobic endurance and functional mobility in adults with and without disease and has shown to be a reliable measure with an intraclass correlation coefficient of > .90 [124].

Subjects were asked to walk as far as possible in 6 minutes around a series of traffic cones placed on a level corridor measuring 100 feet in length, taking rest periods as needed. If the subject required a rest break, they were instructed to resume walking as soon as possible (if able). The number of laps completed was counted by the tester. After 6 minutes, the subject was instructed to stop walking. A marker was placed on the ground and the distance walked during the last lap was measured with a tape measure. The total distance walked was determined by multiplying the number of laps by the circumference of the walking circle and adding the distance covered during the last lap. Heart rate and blood pressure were recorded before and after the walk. Subjects were monitored for signs and symptoms of distress throughout the test. American College of Sports Medicine (ACSM) criteria for test termination were followed. Appendix E details the equipment and participant instructions for the 6-Minute Walk Test.

3.5.6 Measurements to Describe the Sample

The following information was collected on all subjects and used to describe the general characteristics of the study sample.

Demographics: A questionnaire that included questions about age, race or ethnicity, level of education, and past medical history was utilized.

Duke Co-Morbidities Index: The Co-Morbidities Index is a self-report of physician-diagnosed conditions and self-reported symptoms [125]. The Duke Co-Morbidities Index can be found in Appendix F.

Physical Activity Level: The Paffenbarger Physical Activity Questionnaire was used to assess physical activity level of the subjects [126]. This questionnaire has been validated as a tool to assess the weekly physical activity patterns. The three major components of the Paffenbarger Questionnaire are stairs climbed, walking, and sports and recreation. An estimate of the weekly energy expended through leisure time physical activity was calculated using the scoring system devised for this questionnaire, as described by Paffenbarger et al [126].

3.6 DATA ANALYSIS

All data were analyzed using statistical software (SPSS version 17.0). Statistical significance was accepted at the $p < 0.05$ level of confidence.

Demographics (e.g., age, height, weight) of the subjects were described. Descriptive statistics, including measures of central tendency (means, medians, other percentiles) and dispersion (standard deviations, ranges) were computed for each measure. Percentage at the ceiling (highest possible score) and floor (lowest possible score) were calculated for each self-report and performance-based measure of physical function.

3.6.1 Analysis of Primary Aims

1. To examine the association between BMI and self-report measures of physical function in adults.
    - Appropriate correlation coefficients (Spearman rank-order if data are not normally distributed and Pearson if data are normally distributed) were computed between BMI and the measure of function. It was expected that BMI would be negatively correlated with physical function; as BMI increased, physical function would decrease.
2. To examine the association between BMI and performance-based measures of physical function in adults.
    - Appropriate correlation coefficients (Spearman rank-order if data are not normally distributed and Pearson if data are normally distributed) were computed between BMI and the measure of function. It was expected that BMI would be negatively correlated with physical function; as BMI increased, physical function would decrease.

3.6.2 Analysis of Exploratory Aims

1. To examine the difference in self-report measures of physical function between BMI categories (normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class 1 (30.0-34.9 kg/m^2), obese class 2 (35.0-39.9 kg/m^2), and obese class 3 ($\geq$ 40.0 kg/m^2.)
    - The sample was divided based on weight category into 5 groups (normal, overweight, obese class 1, obese class 2 and obese class 3.) Mean scores for the self-report

measure (Late Life Function and Disability Instrument) were computed for each group. Physical function was compared between groups using analysis of variance (ANOVA) with testing for higher order terms to determine if trends exist in physical function as it relates to BMI.

- The sample was divided based on weight category into 5 groups (normal, overweight, obese class 1, obese class 2 and obese class 3.) The Physical Functioning Inventory was used in a qualitative manner to describe limitations in physical function and mean frequencies for reporting difficulty, health-related modifications, and health-related frequency changes were examined in each group. Physical function was compared between groups using chi-square (x^2) analysis.

2. To examine the differences in performance-based measures of physical function between BMI categories (normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class 1 (30-34.9 kg/m^2), obese class 2 (35.0-39.9 kg/m^2), and obese class 3 ($\geq$ 40.0 kg/m^2.)

- The sample was divided based on weight category into 5 groups (normal, overweight, obese class 1, obese class 2 and obese class 3.) Mean values for the performance-based measures were computed for each group. Physical function was compared between groups using analysis of variance (ANOVA) with testing for higher order terms to determine if trends exist in physical function as it relates to BMI.

3. To examine the correlation between self-report and performance-based measures of physical function in adults.

- Appropriate correlation coefficients (Spearman rank-order if data are not normally distributed and Pearson if data are normally distributed) were computed between self-report and performance-based measures of physical function.

4. To examine if BMI influences the relationship between self-report and performance-based measures of physical function in adults.
    - To determine the influence of BMI on in the association between self-report and performance-based measures of physical function, linear regression was used to examine the association between self-report (independent variable) and the performance-based measure of function (dependent variable.) For this analysis, BMI was added to the model to determine its effect on the association between the self-report and performance-based measure. In addition, the sample was divided into 2 groups: normal weight/overweight and obese. The correlation between self-report and performance-based measures was computed for each weight group.
    - To determine the influence of BMI on the association between self-report and performance-based measures of physical function, the sample was divided based on BMI (BMI < 30 kg/m^2 vs. BMI $\geq$ 30 kg/m^2). Select questions from the self-report measure were compared to similar tasks on the performance-based measure. It was expected that compared to those with a BMI < 30 kg/ m^2, a greater percentage of individuals with obesity would inaccurately report ability. Specifically, it was expected that the obese would under-report ability compared to those of normal weight.

3.7 POWER ANALYSIS

A power analysis determined that 47 subjects were required to detect a large effect size to examine the primary aims of this study using correlations with r = .45 with an alpha level set to

.05 (power = .90). This pilot data will be used in sample calculations to determine the appropriate number of subjects needed to conduct future research in this area.

4.0 RESULTS

The purpose of this study was to examine the relationship between BMI and physical function and to assess physical function across BMI categories using self-report and performance-based measures. In addition, the impact of BMI on the relation of self-report and performance-based measures of physical function was explored.

4.1 SUBJECT CHARACTERISTICS

Table 2 provides a summary of demographic variables, physical activity level, and prevalent chronic conditions for all subjects and stratified by weight category. Of the 50 subjects, 10 (20%) were normal weight (BMI between 18.5 and 24.9 kg/m^2), 10 (20%) were overweight (BMI between 25.0 to 29.9 kg/m^2), 10 (20%) were class 1 obese (BMI between 30.0 to 34.9 kg/m^2), 10 (20%) were class 2 obese (BMI between 35.0-39.9 kg/m^2), and 10 (20%) were class 3 obese (BMI $\geq$ 40 kg/m^2). All participants were female, the mean age was 51.2 ± 5.4 years, and most participants classified their race as white (66%). The majority of the subjects reported some degree of college education (86%).

Chi square analyses revealed no differences in ethnicity or level of education between weight groups. Analysis of variance revealed no differences in age between weight categories; however, several characteristics of the subjects were associated with higher BMI categories.

Significant differences were found between weight categories for total number of co-morbid conditions (p = .02). Tukey adjusted post hoc comparisons revealed individuals who were classified as class 1 obese reported a higher total number of co-morbid health conditions compared to those that were normal weight (2.6 ± 0.8 vs. .5 ± .22, p = .04). Chi square analyses revealed a significant difference in prevalence of diabetes between the weight groups (p = .02) with individuals with class 3 obesity reporting the highest percentage compared to the other weight groups. Examination of physical activity data revealed that data were skewed. Thus, differences in physical activity level between weight groups were tested using a non-parametric Kruskal-Wallis test. Results of this analysis revealed significant differences between weight groups in physical activity with the lowest levels found in the higher BMI categories (p = .025).

Table 2 Demographic Characteristics for Total Subjects and for BMI Category

	Total (n=50)	**Normal Weight (n=10)**	**Overweight (n=10)**	**Obese, 1 (n=10)**	**Obese, 2 (n=10)**	**Obese, 3 (n=10)**	**p**
	($\bar{x}$+SD[*])	($\bar{x}$+SD)	($\bar{x}$+SD)	($\bar{x}$+SD)	($\bar{x}$+SD)	($\bar{x}$+SD)	
Age (y)	51.2 ± 5.4	50 ± 1.8	50.4 ± 1.4	53.4 ± 1.6	53.6 ± 1.6	48.6 ± 1.7	.16
BMI (kg/m^2)	33.05±7.7	22.7 ±.5	28.5 ± .3	32.21± .4	37.82± .3	44.03 ± 1.3	.00
Ethnicity	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	
White	66%	14%	12%	16%	10%	14%	.67
Black	34%	6%	8%	4%	10%	6%	
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	
College Educated	86%	20%	14%	18%	18%	20%	.09
Physical Activity Level (kcals/week)	638.55 ± 407.24	983.40 ± 162.35	718.84 ± 133.09	539.28 ±101.02	479.92 ± 75.58	471.32 ± 96.83	.02[1]
# Comorbid Conditions	1.72 ± 1.7	.5 ± .2	1 ± .4	2.6 ± .8	2.2 ± .5	2.3 ± .5	.02[2]
Conditions	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	
Angina	2%	0%	0%	2%	0%	0%	.40
Broken Bone	36%	2%	6%	10%	8%	10%	.30
Heart Failure	2%	0%	0%	2%	0%	0%	.40
Depression	36%	4%	4%	12%	10%	6%	.22
Lung Disorders	18%	2%	2%	4%	6%	4%	.76
Arthritis	30%	2%	2%	8%	10%	8%	.16
Osteoporosis	4%	0%	0%	2%	0%	2%	.54
Diabetes	12%	0%	4%	0%	0%	8%	.02
Sleep Problems	18%	0%	2%	4%	8%	4%	.20
Cancer	2%	0%	0%	0%	0%	2%	.40
Chronic Pain	2%	0%	0%	2%	0%	0%	.40
Cataracts	8%	0%	0%	4%	2%	2%	.43

[*] Standard deviation

[1] p-value for Kruskal-Wallis test

[2] Significant difference between normal weight and class 1 obese (p = .04)

All subjects were able to complete the self-report and performance-based measures. Table 3 represents descriptive statistics including: means, standard deviations, ranges, percentage of subjects at the ceiling (highest possible score) and floor (lowest possible score) for each self-report and performance-based measure of physical function.

None of the subjects scored at the ceiling for the Late Life Function and Disability Instrument (LLFDI) disability frequency total score and no subject scored at the floor for any of the self-report or performance-based measures. A small percentage of subjects (8% and 2%) scored at the ceiling for the LLFDI disability limitation total and function total scores. For the performance-based measures of physical function, only continuous measures were used so a true ceiling effect was not observed. For quality control, the test-retest reliability of the chair rise test was computed using Pearson correlation coefficients in a random sub-sample of subjects (n = 7) and the test was shown to have good reliability (r = .95, p = .001).

Table 3 Descriptive Statistics for Measures of Physical Function for Entire Sample

	Mean (n=50)	SD (n=50)	Range (n=50)	% Ceiling (n=50)	% Floor (n=50)
Self-Report Measure (LLFDI)					
Disability Frequency Total	53.15	5.54	41.99 - 65.07	0%	0%
Disability Limitation Total	72.51	12.6	53.71 - 100.0	8%	0%
Function Total	68.18	10.0	46.11 - 100.0	2%	0%
Performance-Based Measures					
Gait Speed (m/s)	1.15	.21	.82 - 1.61	0%	0%
Chair Rise (s)*	13.13	3.85	8.75 - 31.96	0%	0%
6-Minute Walk (ft)	1,533.54	275.19	1,005 – 2,100	0%	0%

*Test re-test reliability for sub-sample (r = .95, p = .001).

4.2 BMI AND SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

Pearson correlation coefficients were computed to determine the relationship between BMI and the self-report measure of physical function, the LLFDI. Raw scores were transformed into a scaled score ranging from 0-100 using the LLFDI Scoring Software. Three total scores were analyzed using the mean scaled scores: frequency in participating in life tasks (frequency disability total), capability in participating in life tasks (limitation disability total), and ability to perform discrete functional activities without the assistance of others (function total). To allow for more detailed analyses, the frequency total score was further divided into social (9 items) and personal (7 items) participation items, the limitation total score was divided into instrumental (12 items) and management (4 items) scores, and the function total score was separated into upper extremity (7 items), basic lower extremity (14 items) and advanced lower extremity (11 items) scores.

Table 4 provides a description of the relationship between BMI and the LLFDI. A significant correlation was found between BMI and capability in participating in life tasks (LLFDI limitation total) (r = -.45, p = .001), capability in participating in life tasks at home and in the community (instrumental role) (r = -.461, p = .001), capability in participating in social tasks involving management and organization (management role) (r = -.36, p = .01), ability to perform discrete actions and activities without the help of others (LLFDI function total) (r = -.63, p = .000), ability to perform standing and fundamental walking activities (basic lower extremity function) (r = -.502, p = .000), and ability to perform high level functional activities and endurance tasks (advanced lower extremity function) (r = -.729, p = .000).

No significant correlation was found between BMI and frequency in participating in life tasks (LLFDI frequency total), frequency in participating in social and community tasks (social role), frequency in participating in personal tasks (personal role), or ability to perform activities involving the hands and arms (upper extremity function).

Table 4 Correlation between BMI and Self-Report Measure of Function (LLFDI)

MEASURE	BMI (r)	p-value
Frequency Disability Total	-.002	.987
Social Role	.048	.743
Personal Role	-.107	.458
Limitation Disability Total	-.45	.001
Instrumental Role	-.461	.001
Management Role	-.36	.010
Function Total	-.63	.000
Upper Extremity	-.203	.157
Basic Lower Extremity	-.502	.000
Advanced Lower Extremity	-.729	.000

Correlation coefficients were computed to determine the relationship between BMI and the performance-based measures of physical function for the entire sample (Table 5). A significant relationship was found between BMI and chair rise (r_{rank} = .511, p = .000), gait speed (r = -.616, p = .000), and the Six-Minute Walk Test (r = -.562, p = .000).

Table 5 Correlation between BMI and Performance-Based Measures

MEASURE	BMI (r)	p-value
Chair Rise	.511*	.000
Gait Speed	-.616	.000
Six-Minute Walk Test	-.562	.000

*Spearman rank order correlation coefficient computed because data were not normally distributed.

4.3 BMI CATEGORY AND SELF-REPORT MEASURES OF PHYSICAL FUNCTION

Table 6 provides a description of the self-report measure of physical function (LLFDI) stratified by weight group. Significant differences were found between weight categories for the capability in participating in life tasks (LLFDI disability limitation total, p = .000). Tukey adjusted post hoc comparisons revealed differences between normal weight and obese class 2 (80.48 ± 13.09 vs. 64.55 ± 7.98, p = .013), overweight and class 1 obese (82.43 ± 11.8 vs. 66.30 ± 7.98, p = .011), and overweight and class 2 obese (82.43 ± 11.8 vs. 64.55 ± 7.94, p = .004) weight categories. Polynomial contrasts for trend analyses revealed LLFDI disability limitation total score decreased as BMI category increased with a predominant significant linear trend (p_{trend} = .000). However, a significant cubic trend (p_{trend} = .027) was also found reflecting an overall decline in scores with increasing BMI with the exception of the overweight and class 3 obese groups; two groups that had higher scores than the previous weight group.

Significant differences were found between weight categories in capability of participating in life tasks at home and in the community (instrumental role sub-score, p = .000).

Post hoc comparisons revealed differences between normal weight and class 1 obese (81.86 ± 13.97 vs. 66.06 ± 7.93, p = .017), normal weight and class 2 obese (81.86 ± 13.97 vs. 64.33 ± 7.98, p = .006), overweight and class 1 (81.92 ± 11.98 vs. 66.06 ± 7.93, p = .017) and overweight and class 2 (81.92 ± 11.98 vs. 64.33 ± 7.98, p = .006) weight groups. Significant linear (p_{trend} = .000) and cubic (p_{trend} = .04) trends were found indicating that scores decreased with increasing BMI with the exception of the overweight and class 3 obese group in which scores were higher than the previous weight group(s).

Significant differences were also found between weight categories for capability in participating in social tasks involving management and organization (management role sub-score, p = .006), with post hoc comparisons revealing differences between overweight and class 2 obese (96.12 ± 8.25 vs. 76.89 ± 13.29, p = .015) and overweight and class 3 obese (96.12 ± 8.25 vs. 77.89 ± 14.65, p = .024) weight groups. Scores decreased as BMI category increased with the exception of the overweight and class 3 obese groups in which scores were slightly higher than the preceding group. Both linear (p_{trend} = .000) and cubic trends (p_{trend} = .044) were significant.

In the examination of ability to perform discrete functional activities, significant differences were found between weight groups (LLFDI function total, p = .000) with scores decreasing as BMI category increased in a linear fashion (p_{trend} = 000). Post hoc comparisons revealed differences between the normal weight and the obese class 1, 2 and 3 weight categories (79.08 ± 8.55, 65.90 ± 8.13, 61.44 ± 7.19, 62.40 ± 6.20, p = .004, p = .000, p = .000 respectively). For ability to perform standing and fundamental walking activities, significant differences were found between weight categories (basic lower extremity function sub-score, p = .002) with decreased ability as BMI category increased (p_{trend} = .000). Post hoc comparisons revealed differences between normal weight and obese class 1 and 2 groups (94.64 ± 9.02, 72.19 ± 13.37, 78.69 ± 10.90, $p = .008$ and $p = .05$). Significant differences were also found between weight categories for ability to perform high level functional activities and endurance tasks (advanced lower extremity function sub-score, $p = .000$) with a linear trend ($p_{trend} = .000$). Post hoc comparisons revealed differences between normal weight and obese class 1, 2, and 3 (76.80 ± 9.5, 58.43 ± 9.18, 54.12 ± 7.66, 50.53 ± 10.13, $p = .001$, $p = .000$ and $p = .000$ respectively).

There were no significant differences between weight groups for frequency in participating in life tasks (LLFDI disability frequency total), frequency in participating in social and community tasks (social role sub-score), frequency in participating in personal tasks (personal role sub-score), or ability to perform activities with the hands and arms (upper extremity function sub-score). Figures 3, 4, and 5 illustrate the differences between BMI categories for the LLFDI total scores for disability limitation (capability of participating in life tasks), disability frequency (frequency of participation in life tasks) and function (ability to perform discrete functional tasks).

Table 6 Comparison of Self-Reported Function and Disability (LLFDI) between BMI Categories

MEASURE	**Normal Weight**	**Overweight**	**Obese, Class 1**	**Obese, Class 2**	**Obese, Class 3**	**p**
	(Mean+SD)	(Mean+SD)	(Mean+SD)	(Mean+SD)	(Mean+SD)	
DISABILITY COMPONENT **Frequency Total**[1]	54.20 ± 6.19	52.29 ± 5.27	52.07 ± 6.53	53.12 ± 5.24	54.09 ± 5.15	.88
Social Role[2]	50.69 ± 6.95	50.70 ± 9.68	48.68 ± 9.33	49.51 ± 8.77	52.78 ± 9.35	.88
Personal Role[3]	61.8 ± 11.19	54.7 ± 5.47	57.87 ± 11.25	59.79 ± 9.40	56.86 ± 5.63	.47
Limitation Total[4]	80.48 ± 13.09	82.43 ± 11.8	66.30 ± 7.98	64.55 ± 7.94	68.80 ± 10.90	.000
Instrumental Role[5]	81.86 ± 13.97	81.92 ± 11.98	66.06 ± 7.93	64.33 ± 7.98	69.65 ± 11.03	.000
Management Role[6]	89.41 ± 10.53	96.12 ± 8.25	79.99 ± 16.54	76.89 ± 13.29	77.89 ± 14.65	.006
FUNCTION COMPONENT **Function Total**[7]	79.08 ± 8.55	72.10 ± 8.52	65.90 ± 8.13	61.44 ± 7.19	62.40 ± 6.20	.000
Upper Extremity[8]	91.43 ± 10.54	94.45 ± 12.57	88.28 ± 12.96	80.04 ± 14.42	87.63 ± 10.53	.123
Basic Lower Extremity[9]	94.64 ± 9.02	89.64 ± 12.53	80.27 ± 16.12	72.19 ± 13.37	78.69 ± 10.90	.002
Advanced Lower Extremity[10]	76.80 ± 9.5	65.56 ± 10.42	58.43 ± 9.18	54.12 ± 7.66	50.53 ± 10.13	.000

[1] Total score for individual’s regularity of participating in life tasks, i.e. “How often do you do a particular task?”

[2] Within frequency dimension, reflects the frequency of performing social and community tasks.

[3] Within frequency dimension, reflects the frequency of performing personal tasks.

[4] Total score for capability in performing life tasks, i.e. “To what extent do you feel limited in doing a particular task?”

[5] Within the limitation dimension, reflects limitation in activities at home and in the community.

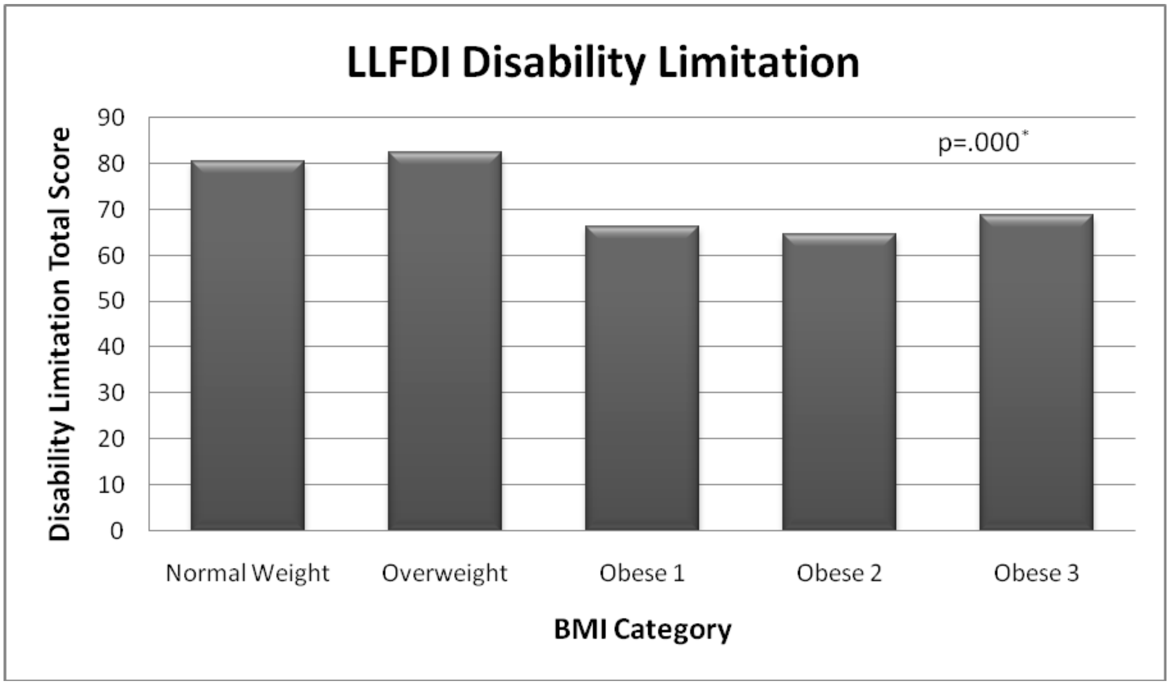
[6] Within the limitation dimension, reflects limitation in organization or management of social tasks that involve minimal mobility/physical activity.

[7] Total score for individual’s ability to do discrete actions or activities without the help of others, i.e. “How much difficulty do you have doing a particular activity without the help of someone else?”

[8] Within function dimension, reflects limitation in activities of the hands and arms.

[9] Within function dimension, reflects limitation in activities involving standing, stooping and fundamental walking activities.

[10] Within function dimension, reflects limitations in activities that involve a high level of physical ability and endurance.



[*] Post hoc analyses revealed difference between normal weight and obese class 2 (p = .013), overweight and class 1 obese (p = .011), and overweight and class 2 obese (p = .004)

Figure 2 Differences in LLFDI Disability Limitation Total Score between BMI Categories

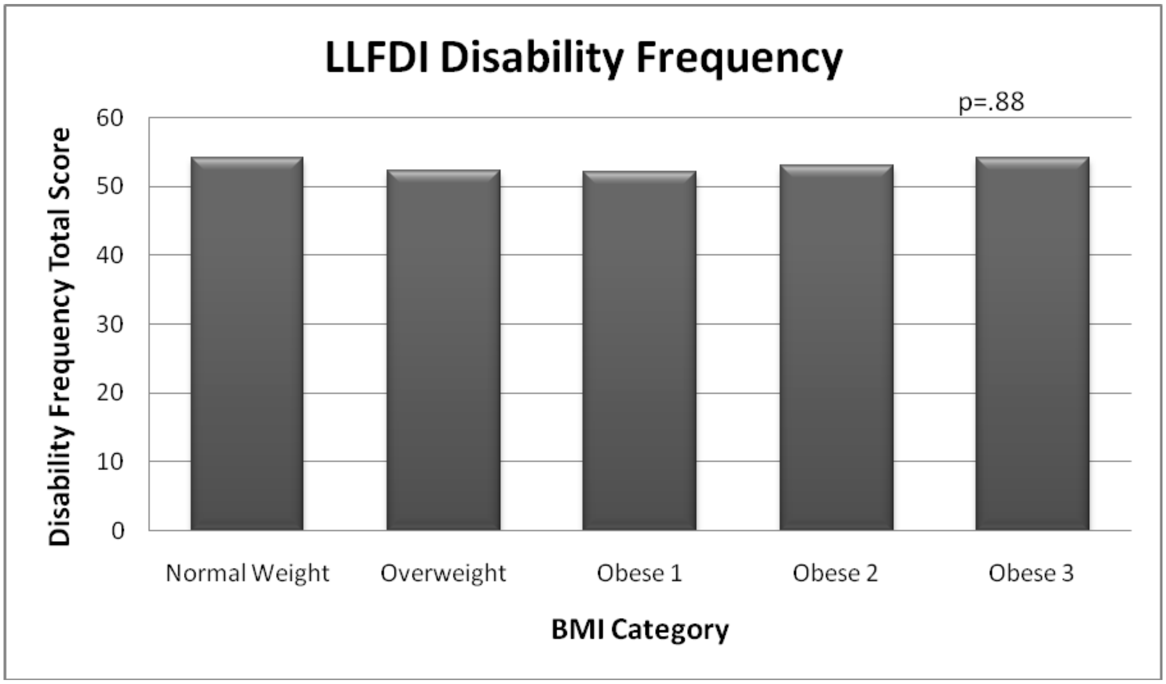
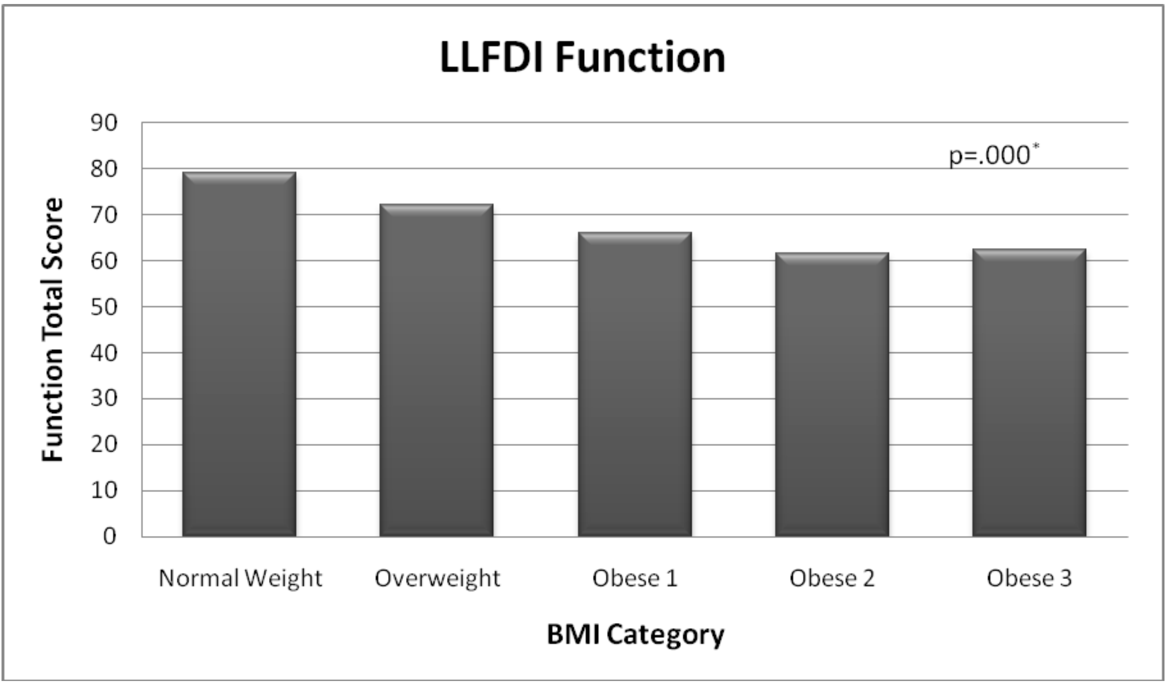


Figure 3 Differences in LLFDI Disability Frequency Total Score between BMI Categories



*Post hoc analyses revealed differences between the normal weight and class 1 (p = .004), class 2 (p = .000) and class 3 (p = .000) obese groups

Figure 4 Differences in LLFDI Function Total Scores between BMI Categories

To further examine the differences in self-report of physical function between BMI categories, mean frequencies for reporting difficulty, health-related modifications, and health-related frequency changes on the Physical Functioning Inventory (PFI) were computed for each BMI group. Table 7 provides the frequency of subjects in each weight category with an affirmative response to each of the following questions: (1) Do you have any difficulty with a specific task? (2) Have you modified or changed the way that you perform a specific task? (3) Have you changed how frequently you perform a specific task? Physical function was compared between groups using Chi-square analysis.

For self-reported difficulty performing specific tasks, there were significant differences between BMI weight groups for difficulty stooping/crouching or kneeling (p = .001) and performing strenuous activities (p = .007), with a greater difficulty reported in the higher BMI categories. For task modification, there were significant differences between weight groups in the frequency of modifying moderate activities (p = .045) with the class 2 obese group reporting the highest percentage of modification (70%). There was a trend observed for higher BMI categories to report task modification for climbing stairs, stooping/crouching, and performing strenuous activities ($p < 0.10$). Furthermore, there were significant differences between weight groups in the report of decreased frequency for climbing stairs (p = .012), walking 5-6 blocks (p = .034), and performing moderate and strenuous activities (p = .000) with reduced frequency found in higher BMI categories.

For each task in which difficulty or modification of activity was reported, subjects were asked to report what they perceived as the associated medical conditions. Being overweight was the condition most often cited for difficulty/modification of climbing stairs, walking ½ mile, stooping and crouching, and performing moderate and strenuous activities. The second most frequently cited medical condition was arthritis. Subjects were also asked to identify the most strenuous activity that they currently perform. In the obese groups, 37% of the participants identified “carrying items up and down the stairs” as their most strenuous task.

Table 7 Description of Physical Function Inventory Stratified by Weight Group

PHYSICAL FUNCTIONING INVENTORY	Normal Weight (% Weight Group)	Over-weight (% Weight Group)	Obese, Class 1 (% Weight Group)	Obese, Class 2 (% Weight Group)	Obese, Class 3 (% Weight Group)	p-value Chi Square
Reported Difficulty						
Climbing Stairs	0%	10%	30%	30%	20%	.330
Walking ½ Mile	0%	10%	20%	10%	20%	.618
Stooping, Crouching	0%	40%	70%	80%	80%	.001
Moderate Activities	0%	10%	10%	30%	30%	.253
Strenuous Activities	20%	70%	80%	80%	90%	.007
Modified Task						
Climbing Stairs	0%	30%	60%	50%	50%	.056
Walking ½ Mile	0%	30%	40%	40%	50%	.152
Stooping, Crouching	10%	40%	70%	60%	60%	.083
Moderate Activities	0%	10%	20%	70%	30%	.045
Strenuous Activities	40%	60%	80%	90%	90%	.054
Decreased Frequency						
Climbing Stairs	0%	0%	20%	60%	50%	.012
Walking ½ Mile	0%	10%	40%	60%	50%	.034
Stooping, Crouching	20%	30%	50%	80%	50%	.110
Moderate Activities	0%	0%	30%	60%	40%	.003
Strenuous Activities	50%	60%	100%	100%	100%	.000

4.4 BMI CATEGORY AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

Table 8 provides a description of performance-based measures stratified by weight group. Significant differences were found between weight groups for gait speed (p = .000) (Figure 6). Polynomial contrasts revealed a significant linear trend indicating that gait speed decreased as BMI category increased (p_{trend} = .000). Tukey adjusted post hoc comparisons revealed significant differences between normal weight, class 2 and class 3 obese (1.35 m/sec vs. 1.04 m/sec vs. .97 m/sec, p = .002 and .000. respectively) and overweight and class 3 obese (1.20 m/sec vs. .97 m/sec, p = .034). Significant differences were also found between weight groups for the Six-Minute Walk Test distance (p = .001) (Figure 7). Walking distance decreased linearly as BMI category increased (p_{trend} = .000). Tukey adjusted post hoc comparisons revealed differences between the normal weight and class 1, 2, and 3 obese (1,790 feet vs. 1,472 feet, vs. 1476 feet vs. 1,331 feet, p = .034, p = .038 and p = .003 respectively). Because data were not normally distributed for the chair stand test, non-parametric statistics were utilized in the analyses. Significant differences were found between weight groups (p = .015) using a Kruskal-Wallis ANOVA (Figure 8). Mann-Whitney analyses with p-value adjusted using the Bonferroni procedure revealed the time for completion for the normal weight group was significantly lower than the obese class 2 group (p = .004) and the class 3 obese group (p = .001).

Table 8 Description of Performance-Based Measures Stratified by Weight Group

	Normal Weight	Overweight	Obese, Class 1	Obese, Class 2	Obese, Class 3	p
	(Mean+SD)	(Mean+SD)	(Mean+SD)	(Mean+SD)	(Mean+SD)	
Gait Speed (m/sec)	1.35 ± .06	1.20 ± .59	1.17 ± .07	1.04 ± .04	.97 ± .04	.000[1]
6-Minute Walk (feet)	1790 ± 82.79	1598 ± 68.29	1472 ± 90.60	1476 ± 75.73	1331 ± 51.54	.001[2]
Chair Stands (sec)	10.56 ± .43	12.48 ± 1.15	13.11 ± .75	13.83 ± .93	15.64 ± 1.90	.015[3]

[1] Significant differences between normal weight and class 2 obese (p = .002), normal weight and class 3 obese (p = .000), overweight and class 3 obese (p = .034)

[2] Significant differences between normal weight and class 1 obese (p = .034), normal weight and class 2 obese (p = .038), normal weight and class 3 obese (p = .003)

[3] Significant differences between normal weight and class 2 obese (p = .004) and normal weight and class 3 obese (p = .001)

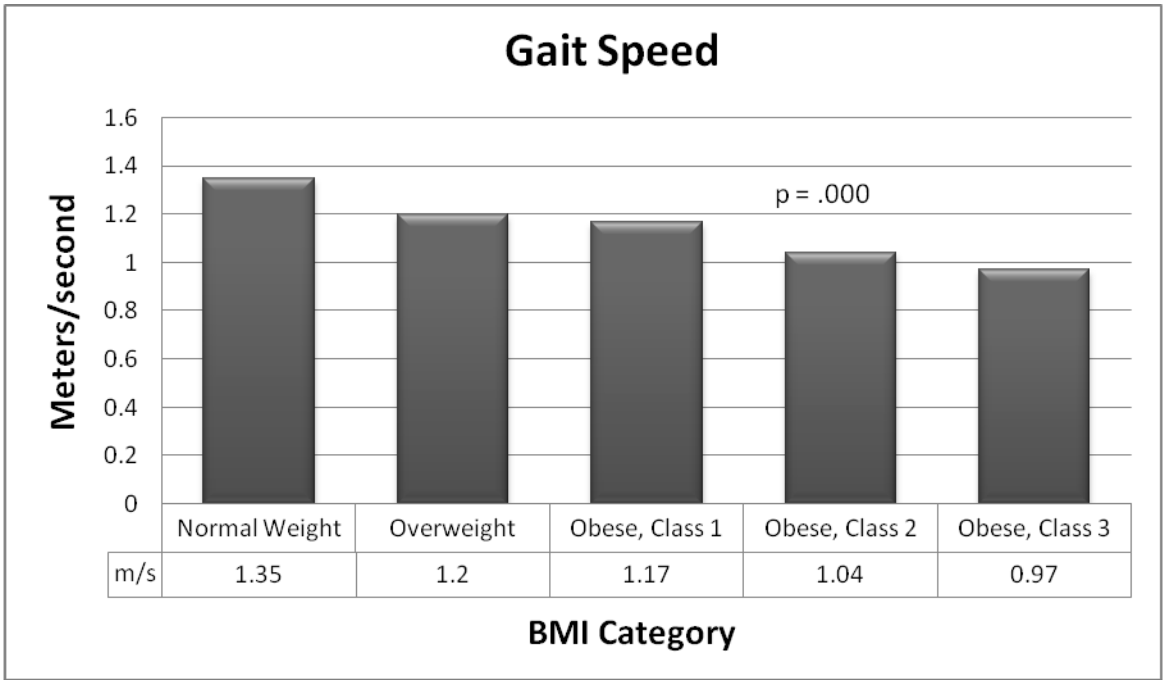


Figure 5 Gait Speed Stratified by BMI Category

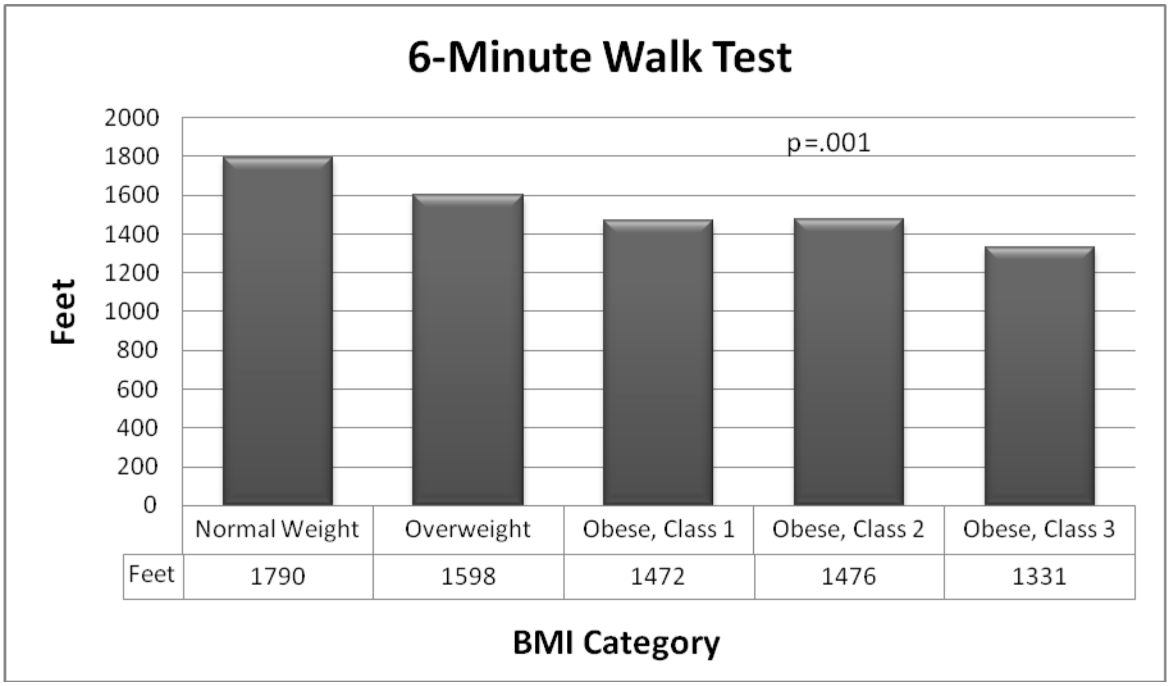


Figure 6 Six-Minute Walk Test Distance Stratified by BMI Category

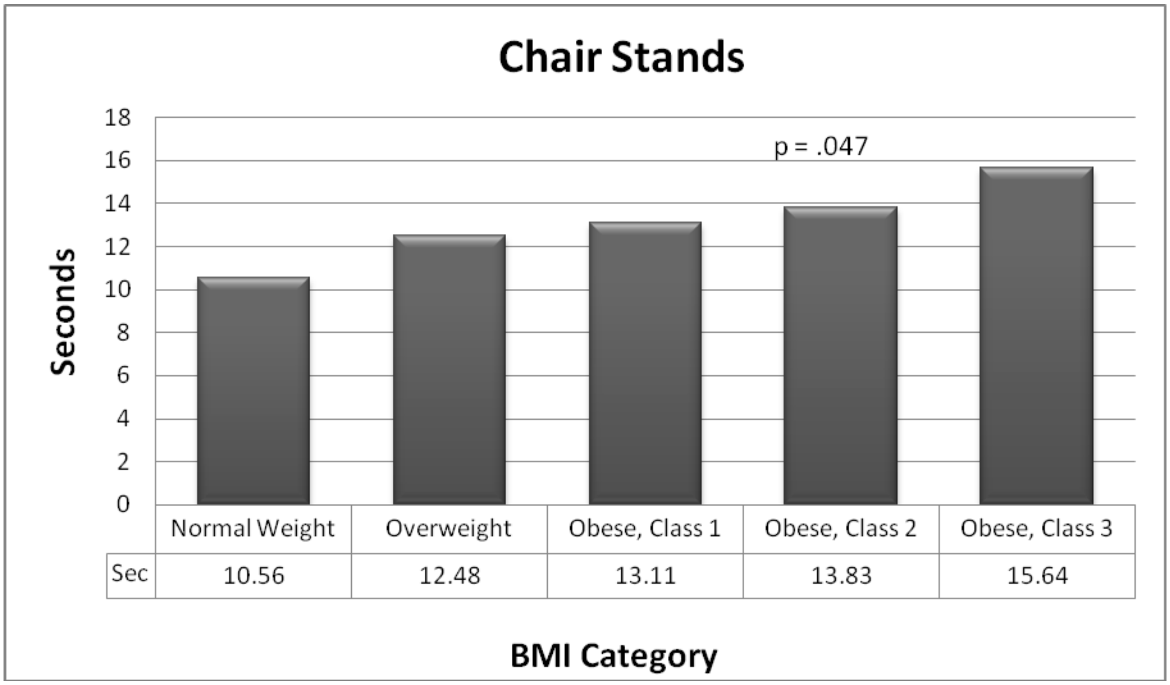


Figure 7 Chair Stands Stratified by BMI Category

4.5 RELATIONSHIP BETWEEN SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

To examine the relationship between self-report and performance-based measures of physical function, correlation coefficients were computed between the measures. Table 9 describes the correlation between self-report and performance-based measures. A significant relationship was found between the LLFDI disability limitation total score and chair stands (r_{rank} = -.360, p = .010) and the 6-Minute Walk Test distance (r = .292, p = .039). LLFDI instrumental role sub-score and chair stands were significantly correlated (r_{rank} = -.359, p = .01) as well as LLFDI management role sub-score and 6-Minute Walk Test distance (r = .302, p = .033).

The LLFDI function total was significantly correlated with all performance-based measures: chair stands (r_{rank} = -.516, p = .000), gait speed (r = .646, p = .000), and the 6-Minute Walk Test distance (r = .600, p = .000). Basic lower extremity sub-score was significantly related to all performance-based measures: chair stands (r_{rank} = -.459, p = .001), gait speed (r = .476, p = .000), and the 6-Minute Walk Test distance (r = .445, p = .001). In addition, the advanced lower extremity sub-score was significantly correlated with all performance-based measures: chair stands (r_{rank} = -.545, p = .000), gait speed (r = .637, p = .000), and the 6-Minute Walk Test distance (r = .62, p = .000).

No significant relationships were found between the LLFDI disability frequency total score, social role sub-score, personal role sub-score, upper extremity sub-score and any of the performance-based measures.

Table 9 Correlation between Self-Report and Performance-Based Measures

	Chair Stands[*]		**Gait Speed**		**6-Minute Walk Test**	
	r_{rank}	p-value	r	p-value	r	p-value
LLFDI Disability Frequency Total	-.098	.500	-.062	.669	.114	.432
Social Role	-.127	.379	-.01	.945	.143	.321
Personal Role	-.008	.958	-.118	.414	.089	.539
LLFDI Disability Limitation Total	-.360	.010	.215	.130	.292	.039
Instrumental Role	-.359	.01	.19	.186	.27	.058
Management Role	-.271	.057	.249	.082	.302	.033
LLFDI Function Total	-.516	.000	.646	.000	.600	.000
Upper Extremity	-.151	.295	.252	.078	.186	.197
Basic Lower Extremity	-.459	.001	.476	.000	.445	.001
Advanced Lower Extremity	-.545	.000	.637	.000	.620	.000

[*] Spearman rank order correlation coefficient computed because data were not normally distributed

4.6 THE IMPACT OF BMI ON THE RELATIONSHIP BETWEEN SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

To examine the effect of BMI on the relationship between self-report and performance-based measures of physical function, linear regression was utilized. In the first model, the self-report measure (LLFDI advanced lower extremity score) was utilized as the predictor and the performance-based measure (gait speed) as the dependent variable. The self-report measure significantly predicted the performance, Beta = .621, $p < .001$. In the second model, the self-report measure (LLFDI advanced lower extremity score) and BMI were added to the model as predictors with the performance-based measure (gait speed) as the dependent variable. In the second model, BMI attenuated the relationship between the self-report measure and the performance-based measure, Beta = .367, $p = .026$ (Table 10).

Table 10 Linear Regression Analysis Predicting Performance (Gait Speed) from Self-Reported Physical Function (LLFDI) and BMI

	Model 1		**Model 2**	
	Beta coefficient	p-value	Beta coefficient	p-value
Dependent Variable - Gait Speed **Self-Report Measure of Physical Function**	.621	.000	.367	.026
Body Mass Index	---	---	-.348	.034

Model 1: adjusted R^2= .373, F= 30.17, $p < .001$, Model 2: adjusted R^2 = .419, F = 18.66, $p < .001$

To further explore the impact of BMI on the relationship between self-report and performance-based measures of physical function, the sample was divided into two groups: normal/overweight (BMI < 30 kg/m^2) and obese (BMI $\geq$ 30 kg/m^2). The correlation between the self-report measure (LLFDI advanced lower extremity score) and each performance-based measure was computed using Pearson correlation coefficients.

For the normal weight/overweight group, the LLFDI score was significantly correlated with all performance-based measures: gait speed ($r = .634$, $p = .003$), chair rise ($r_{rank} = -.557$, $p = .011$), and the 6-Minute Walk Test ($r = .466$ $p = .039$). However, for the obese group, the LLFDI score was significantly correlated with the 6-Minute Walk Test only ($r = .418$, $p = .021$) (Table 11). Figures 9, 10, and 11 illustrate of the relationship between the LLFDI advanced lower extremity score and gait speed, chair rise, and the 6-Minute Walk test for subjects in the normal weight/overweight group (BMI < 30 kg/m^2) compared to subjects in the obese group (BMI $\geq$ 30 kg/m^2).

Table 11 Correlation between Self-Report and Performance-Based Measures According to BMI

	LLFDI and Gait Speed		**LLFDI and Chair Rise[*]**		**LLFDI and 6-Minute Walk Test**	
	r	p-value	r_{rank}	p-value	r	p-value
BMI < 30 kg/m^2	.634	.003	-.557	.011	.466	.039
BMI $\geq$ 30 kg/m^2	.32	.085	-.150	.430	.418	.021

[*] Spearman rank order correlation coefficient computed because data were not normally distributed

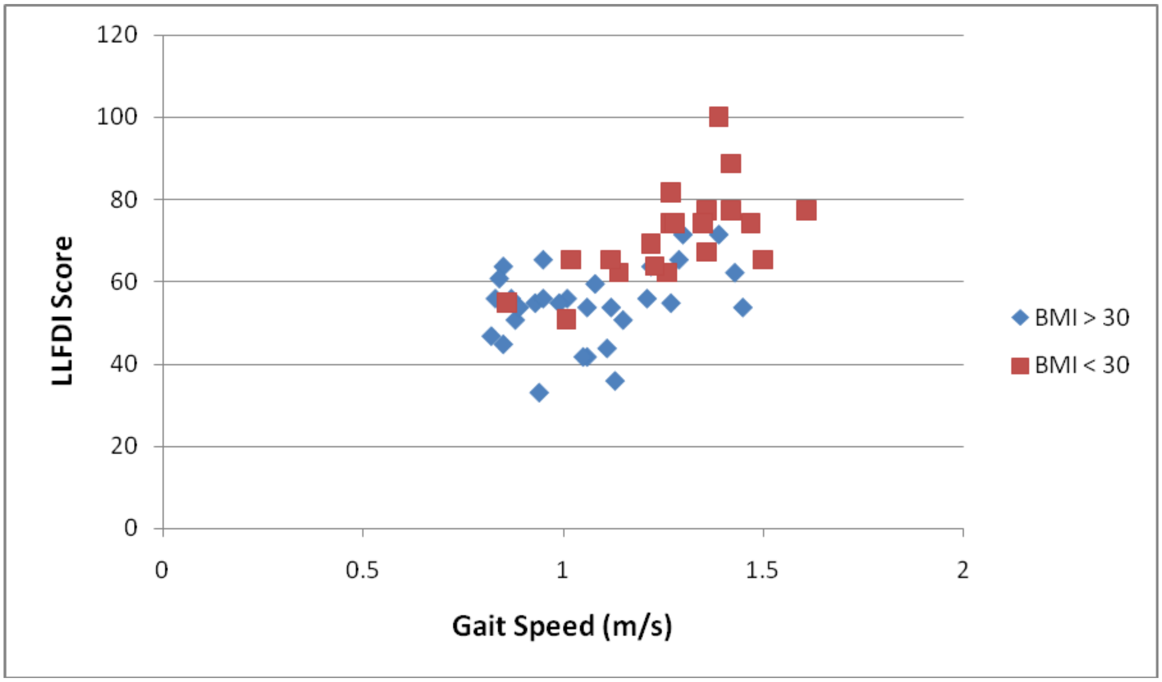


Figure 8 Relationship between Self-Report and Performance-Based Measure (Gait Speed) According to BMI

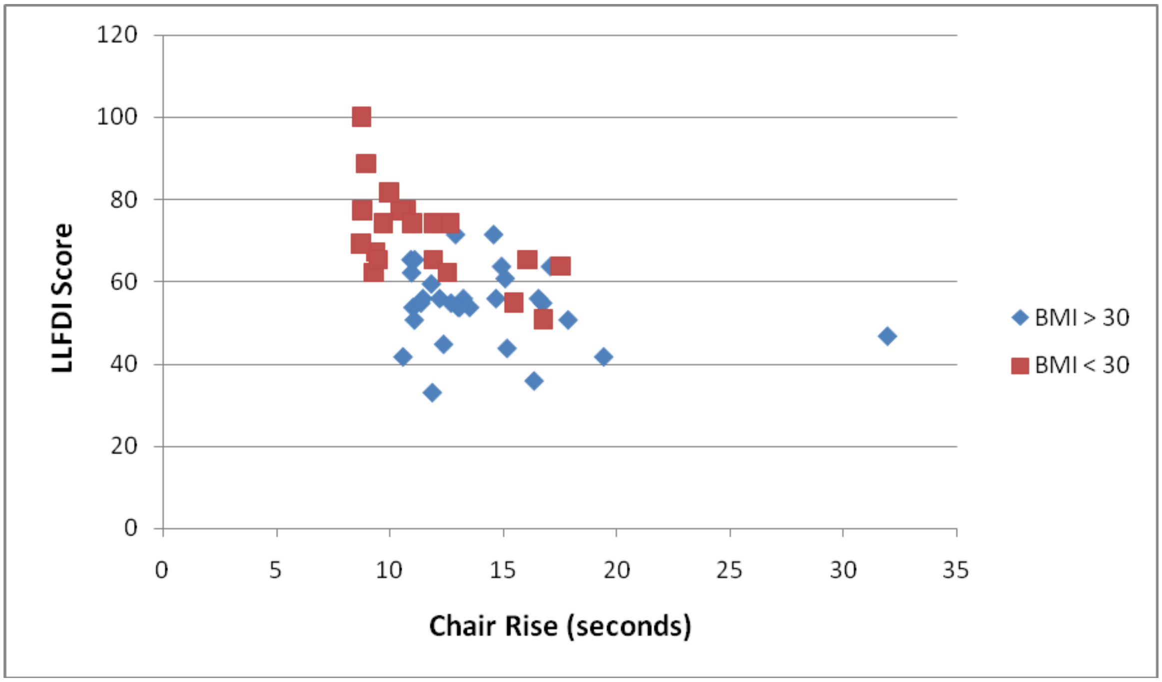


Figure 9 Relationship between Self-Report and Performance-Based Measure (Chair Rise) According to BMI

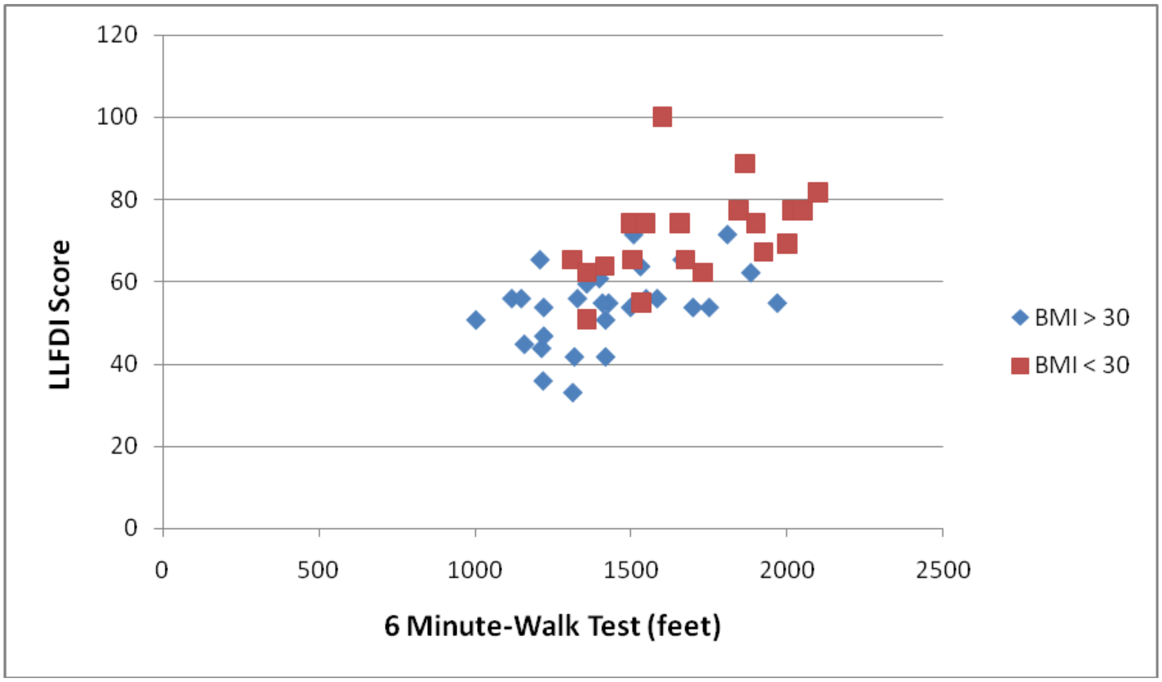


Figure 10 Relationship between Self-Report and Performance-Based Measure (6-MWT) According to BMI

Reported difficulty walking (subjects who reported having difficulty walking 1 mile, taking rests as necessary) on self-report measure (LLFDI) was compared to performance on the 6-Minute Walk Test. Subjects were classified as having difficulty walking on the 6-Minute Walk Test if they performed < 75% of the predicted value based on reference equations for adult women [127]. Because the groups had unequal numbers of subjects, only descriptive statistics are reported.

A greater number of subjects in the normal weight/overweight group (BMI < 30 kg/m^2) performed and reported similar levels of walking ability compared to the obese group (BMI $\geq$ 30 kg/m^2) (100% vs. 60%). Of the obese women whose performance was different from their report, 37% reported difficulty walking when they did not have difficulty walking and 3% did not report difficulty when they had difficulty walking (Table 12).

Reported difficulty walking (subjects who reported difficulty walking ½ mile) on the self-report measure (PFI) was compared to gait speed performance. Subjects were classified as having difficulty walking if their walking speed was < 1.0 m/s based on previous reports that have established 1.0 meters/second as a cut-point for identification of high risk health related-events in well-functioning older adults [95]. Results showed that a greater number of subjects in the normal weight/overweight group performed and reported similar levels of walking ability compared to the obese group (90% vs. 54%). Of the obese subjects whose performance was different from their report, 10% reported difficulty walking when they did not have difficulty and 37% did not report difficulty when they had difficulty walking (Table 13).

Table 12 First Comparison of Self-Report and Performance According to BMI

Reported Difficulty Walking[1] **Had Difficulty Walking**[2]	**Yes** **Yes**	**Yes** **No**	**No** **Yes**	**No** **No**
	% of group	% of group	% of group	% of group
BMI < 30 kg/m^2	10%	0%	0%	90%
BMI $\geq$ 30 kg/m^2	10%	37%	3%	50%

[1] Subjects who reporting having difficulty walking 1 mile, taking rests as necessary, on the LLFDI.
[2] Subjects who performed < 75% of the predicted value on the 6-Minute Walk Test based on reference equations for adult women.

Table 13 Second Comparison of Self-Report and Performance According to BMI

Reported Difficulty Walking[3] **Had Difficulty Walking**[4]	**Yes** **Yes**	**Yes** **No**	**No** **Yes**	**No** **No**
	% of group	% of group	% of group	% of group
BMI < 30 kg/m^2	0%	5%	5%	90%
BMI $\geq$ 30 kg/m^2	7%	10%	37%	47%

[3] Subjects who reporting having difficulty walking ½ mile on the Physical Functioning Inventory.
[4] Subjects who performed at a gait speed < 1.0 meter/second.

4.7 SUMMARY OF RESULTS

Results of the current study demonstrated BMI was significantly related to self-report and performance-based measures of physical function. As BMI increased, physical function level decreased. Compared to those that were classified as normal weight and overweight, participants that were classified as obese had poorer levels of physical function on both types of measures. In addition, results showed that a large percentage of participants in the obese groups reported changes in how or how often they performed every day activities such as walking, stair climbing and stooping/crouching and kneeling. The majority of participants in the obese groups cited “overweight” as the primary condition associated with their limitations. While the performance-based and self-report measures of function were moderately correlated in the sample, the association between the measures was significantly stronger for the normal weight/overweight groups compared to the obese groups. Furthermore, compared to those in the lower BMI categories, a greater number of obese individuals performed differently on walking tests compared to their report.

5.0 DISCUSSION

5.1 INTRODUCTION

The primary purpose of this study was to assess physical function in adults across the range of BMI categories using self-report and performance-based measures and to examine the impact of BMI on the relation of these measures. This study focused on examining two primary aims: (1) To examine the association between BMI and self-report measures of physical function in adults; and, (2) To examine the association between BMI and performance-based measures of physical function in adults. There were also 4 exploratory aims: (1) To examine the difference in self-report measures of physical function between BMI categories (normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class 1 (30-34.9 kg/m^2), obese class 2 (35.0-39.9 kg/m^2), and obese class 3 ($\geq$ 40 kg/m^2); (2) To examine the differences in performance-based measures of physical function between BMI categories (normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class 1 (30-34.9 kg/m^2), obese class 2 (35.0-39.9 kg/m^2), and obese class 3 ($\geq$ 40 kg/m^2); (3) To examine the correlation between self-report and performance-based measures of function in adults; and, (4) To examine if BMI influences the relationship between self-report and performance-based measures of physical function in adults.

5.2 DESCRIPTION OF SELF-REPORT AND PERFORMANCE-BASED MEASURES

In this sample of relatively high-functioning adult women, only a small percentage of participants scored at the ceiling for the self-report measure (0%, 2%, and 8% for the LLFDI frequency, function, and limitation total scores respectively) and none of the subjects scored at the floor. These findings are consistent with previous reports of a low incidence of ceiling and floor effects using the LLFDI [120]. Alternative self-report measures of physical function have been shown to have a larger ceiling effect in high-functioning populations [19, 20]. However, the LLFDI was designed to detect limitations in physical function across the spectrum of abilities [128]. The results indicate this self-report measure is sensitive in measuring disability and function in a higher-functioning sample of adult women.

All subjects were able to complete the performance-based measures of physical function and no subject scored at the floor or ceiling for the measures because of the continuous nature of the variables. The 6-Minute Walk test was utilized as a measure of functional mobility and aerobic endurance. This commonly used walk test is self-paced and allows the individual to rest as needed during the test. Previous studies have reported lower completion rates and a higher prevalence of subject discomfort when using alternative walking tests such as the 400-meter walk and the 2-km walk test for assessment of functional capacity [129, 130]. Based on the high completion rate and low incidence of subject discomfort in the current study, the 6-Minute-Walk test is deemed to be a feasible test for use in adult women across the spectrum of BMI categories. In particular, the 6-Minute Walk test may be useful in providing an objective baseline measure of functional exercise capacity in individuals with higher BMI's ($\geq$ 40 kg/m^2) that have difficulty performing standard treadmill tests.

5.3 PRIMARY AIM 1: TO EXAMINE THE ASSOCIATION BETWEEN BMI AND SELF-REPORT MEASURES OF PHYSICAL FUNCTION

Results showed BMI was significantly related to self-reported capability in participating in life tasks and ability to perform discrete functional activities involving the lower extremities. As BMI increased, participants reported more limitations in ability to perform life tasks and more difficulty in performing functional activities such as standing, walking and climbing stairs (Table 4). These findings are supported in previous studies which have found lower levels of self-reported physical function and greater role limitation in adult and older adult women with higher BMI's [7, 47, 72].

Conversely, BMI was not related to ability to perform activities involving the hands and arms. Thus in the current study, higher BMI had a negative effect on functional activities involving the lower extremities but not activities involving the upper extremities. This is in contrast to previous studies of older women that have shown those with higher BMI's also had greater difficulty performing tasks involving in upper extremity function and activities of daily living involving the arms [17, 76]. The current study did not include an objective measure of upper extremity function and examined a younger population, and this may partially explain differences when comparing this study to other studies in the published literature.

BMI was not related to self-reported frequency in participating in life tasks. Although participants with higher BMI's felt significantly more limited, there were no differences in the level of participation with which they performed life tasks compared to those with lower BMI's. This may have been observed due to the relatively younger age of the participants. Across all weight groups, many participants reported they were employed full-time and/or caring for children at home; as a result, they may have continued to participate in life activities such as taking care of finances, household business, and local errands whether they felt limited or not. This indicates that varying ranges of frequency in task performance may exist within each functional level. These findings have implications for the selection of tests and measures of physical function in adult women with obesity. It may be more important to select measures that focus on perceived limitations as opposed to actual level of participation in functional tasks.

5.4 PRIMARY AIM 2: TO EXAMINE THE ASSOCIATION BETWEEN BMI AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

Results from this study showed higher BMI was associated with poorer physical function on each of the performance-based measures (Table 5). Of the performance-based measures, high BMI was most strongly related to gait speed and the 6-Minute Walk test (r = -.616, p = .000 and r = -.562, p = .000). These findings are consistent with results of previous studies that have examined walking performance in adults with obesity. Specifically, researchers have shown that individuals with higher BMI's have more difficulty walking compared to lean counterparts as a result of decreased cadence and stride length as well as increased step width [90, 92, 93]. It is believed that slower gait speed in the obese may result from increased lateral motion of the legs during swing phase of gait, leading to decreased forward momentum [75, 90, 92, 93]. In addition to gait abnormalities observed in the obese, individuals with higher BMI's have more knee pain, foot and heel pain, low back pain, skin friction, and stress incontinence compared to those of normal weight; all of which are likely to have a negative impact on walking ability [10, 41, 97, 131, 132].

5.5 EXPLORATORY AIM 1: TO EXAMINE THE DIFFERENCE IN SELF-REPORT MEAURES OF PHYSICAL FUNCTION BETWEEN BMI CATEGORIES

It was hypothesized there would be a gradient effect of BMI on physical function with individuals with class 3 obesity reporting the most limitation in function, followed in descending order by individuals with class 2 obesity, class 1 obesity, overweight, and normal weight adults. The results showed that participants categorized as obese felt more limited in performing life tasks compared to those that were normal weight and overweight. In addition, participants that were obese reported more difficulty performing functional activities compared to those of normal weight (Table 6).

Differences in physical function were most apparent in tasks that involved the lower extremities including mobility tasks. Interestingly, those in the class 3 obese group reported slightly less limitation in function compared to those in the class 1 and 2 obese groups. It is believed that this may have been due to the small sample size and the difference in age of the participants in the class 3 obese group. Though not statistically significant, participants in this group were approximately 5 years younger in age compared to the participants in class 1 and 2 obese weight groups (48.6 compared to 53.4 and 53.6 years).

Mean scaled summary scores of the LLFDI have been classified into 4 different sub-groups for clinical interpretation: severe limitations, moderate limitations, slight limitations and no limitations (Appendix G) [128]. Participants that were classified as normal weight and overweight exhibited scores consistent with no limitations in capability of participating in life tasks and no limitations in performing discrete functional activities. In contrast, participants in the obese groups exhibited scores consistent with slight to moderate limitation in each of these areas (Table 6).

The current findings indicate that functional level may deteriorate once an individual reaches a threshold BMI level (i.e. BMI $\geq$ 30 kg/m^2). The results of this study are consistent with prior research showing lower levels of physical function in individuals approaching a BMI of 30 kg/m^2 [7]. Coakley et al found a significant dose-response relationship between increasing levels of BMI and lower levels of self-reported physical function. In women 45-71 years of age, function decreased by approximately 5.5% among the moderately overweight (BMI 28 - 29.9 kg/m^2) compared to those of normal weight. Similar to findings of the current study, significantly lower levels of function were noted in women at higher levels of obesity. For example, those with a BMI > 30 kg/m^2 experienced a 10% decrease in function and those with a BMI > 35 kg/m^2 had 14-16% lower functioning compared to the normal weight reference group.

Other researchers have reported that physical function deteriorates at a higher BMI level ($\geq$ 35 kg/m^2) than that found in the current study [133]. However, a difference in the way that functional impairment was defined is likely to account for the discrepancy. For example, in the above referenced study, Friedmann et al defined impairment in function as needing assistance with a functional activity [72]. In the current study, impairment was defined as reporting a degree of difficulty with the functional task. As a result, the measure used by Friedman was more likely to identify individuals at a later stage in the spectrum of disability compared to the self-report measure used in this study, which was likely to identify individuals at an earlier stage of decline.

The second self-report measure utilized, the Physical Functioning Inventory (PFI), was designed to detect several dimensions of change in physical function: difficulty, modification, and / or change in frequency of task performance [118]. In the current study, individuals in the higher BMI groups reported more difficulty stooping and crouching and performing strenuous activities on the PFI compared to those in lower BMI categories (Table 7). None of the subjects in the normal weight group reported difficulty performing functional tasks such as climbing stairs, walking, or stooping and crouching; however, report of difficulty for each of these tasks began to increase in the overweight group and was most pronounced in the obese groups.

According to Fried et al, the reported change in how or how often a task is performed defines two aspects of a preclinical state of functional loss [134, 135]. When examining changes in how a task was performed in the current study, participants classified as obese were more likely to modify the way they performed moderate activities. In addition, a large percentage of those in the obese groups reported modification of climbing stairs ($\geq$ 50%), stooping and crouching ($\geq$ 60%), and performing strenuous activities ($\geq$ 80%). Furthermore, a large number of participants with higher levels of obesity reported a decrease in how often (frequency) they climb stairs (50-60%) , walk ½ mile (50-60%), and perform moderate (40-60%) and strenuous activities (100%).

Previous research has shown that modification or change in frequency of task performance represents an intermediate stage of function prior to the onset of disability [134, 135]. In a prospective study of older adult females, those who reported modification or change in frequency of a task were approximately four times higher risk for mobility disability compared to those reporting no compensations or difficulties [134]. Based on this, a large proportion of obese women in this sample appear to be at higher risk of mobility disability compared to those classified as normal weight and overweight. Individuals in this high risk “transition stage” of physical functioning may be an optimal target group for interventions, such as weight loss programs, to prevent progression to disability. Despite the adaptive changes in how or how often they perform a functional task, these individuals may be more responsive to a physical activity intervention because they are likely to be functioning at a level of independence that would allow optimal participation. In contrast, individuals with more severe obesity (BMI > 40 kg/m^2) are more likely to be disabled and may require a dietary weight loss program and/or rehabilitation prior to being able to fully engage in a physical activity intervention.

The Physical Functioning Inventory revealed that high BMI had the most detrimental effect on functional activities such as bending, crouching, kneeling, and stair climbing, all of which require an individual to lift their body weight against gravity. Other researchers have identified similar tasks that pose more difficulty for individuals with obesity compared to those that are more lean. In a study of adults aged 20-59 years, overweight women had most difficulty bending, kneeling and stooping and climbing stairs compared to those in a lower weight category [47]. Similarly, Evers and Larsson found that middle aged women with obesity had the most difficulty performing activities at floor level, bending and kneeling, and climbing stairs [9]. Because research has shown that physical function is improved with weight loss achieved through physical activity and dietary interventions [11, 100-103], the identification of tasks which present the greatest difficulty for the obese should guide the selection of outcome measures that will most accurately portray improvements in functional abilities.

5.6 EXPLORATORY AIM 2: TO EXAMINE THE DIFFERENCE IN PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION BETWEEN BMI CATEGORIES

On the performance-based measures, participants that were normal weight and overweight performed similarly; however, those classified as obese had poorer performance (Table 8). In this sample of relatively younger, high-functioning females, only the normal weight and overweight groups achieved desirable gait speeds ($\geq$ 1.2 m/s) based on previous studies in older adults [95]. For each of the obese categories, the mean gait speed was < 1.2 m/s, which may have implications for these individuals to function successfully in the community. For example, in order to safely negotiate through a traffic intersection, an individual must be able to walk at a speed of 1.2 m/s. Furthermore, the mean gait speed of .97 m/s observed in participants in the obese class 3 category is not just indicative of impaired functioning, but in addition, individuals with usual gait speeds < 1.0 m/s are deemed higher risk for a number of adverse health events including nursing home admission, falls, and disability [95].

The finding that gait speed is most impaired in individuals with class 3 obesity is supported in previous studies. In an analysis of the kinematic components of gait in adults with obesity, Spyropoulos and colleagues found that individuals with obesity walked much slower than those of normal weight (1.09 m/sec vs. 1.64 m/sec, $p < .001$). While these subjects had faster gait speeds than participants in the current study, the subjects were also younger in age (30 to 47 years) [92]. de Souza et al analyzed the gait of 34 obese individuals and found that subjects walked at a mean gait speed of .73 m/s, also placing them in a high risk category. In the latter study, participants were more similar in age to those in the current study ($\bar{x}$ = 47.2 years) [90]. These findings underscore the negative impact that high BMI has on locomotion, even in apparently healthy middle-aged women.

Performance on the 6 Minute-Walk test and the timed chair stands declined as BMI category increased. However, while normal weight and overweight individuals performed similarly, it was the individuals with obesity that displayed poorer performance. The finding that physical function deteriorated at BMI's $\geq$ 30 kg/m^2 on the performance-based measures was consistent with the results found in the analyses of the self-report measure.

5.7 EXPLORATORY AIM 3: TO EXAMINE THE CORRELATION BETWEEN SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

The results showed that the self-report and performance-based measures were related. Specifically, the participants' perceived limitation in performing life tasks was weakly correlated with performance-based measures. In addition, perceived ability to complete functional tasks was moderately correlated to performance-based measures. Because the performance-based tests measured discrete lower extremity tasks and mobility, it was not surprising that they were most strongly related to self-reported lower extremity function. Conversely, performance-based measures were not related to the frequency with which participants performed life activities (Table 9).

Previous researchers have found similar relationships between performance-based measures and the function and disability components of the LLFDI in older adults [120]. In a study by Sayers et al, performance-based measures of physical function were most strongly related to perceived function and limitations in completing life tasks. However, similar to the current study, no association was found between performance-based measures and frequency of performing life tasks [120]. The finding that the frequency with which an individual performs an activity is not related to physical performance implies that physical disability is not simply the inability to perform a task, but is influenced by environmental and behavioral factors [120].

The moderate correlation found between self-reported lower extremity function and the performance-based measures is consistent with results reported in previous studies [19, 136, 137]. Prior research indicates that self-report and performance-based measures may have tap into different levels of the physical function hierarchy [19]. In addition, the lack of a stronger relationship between the measures in this study may result from a discrepancy between perception and ability.

In this sample of higher functioning adult women, the self-report and performance-based measures uniquely contributed to the description of physical function. While the self-report measure defined perceived limitations in performing life tasks, the performance-based measure depicted what the individual was actually capable of doing. Each measure had distinct advantages and disadvantages. The performance-based measures, though more objective in nature, included a small number of discrete tasks performed in a controlled environment. The self-report measure complimented the performance-based measure by measuring the individual's perceived ability to perform in socially defined roles and tasks, which the performance-based measure was not capable of doing [19].

The author contends that each type of measure provides critical information in the assessment of physical function in adult women at varying BMI levels. Furthermore, it is believed that a combination of measures would most accurately depict the efficacy of interventions aimed to improve physical functioning.

5.8 EXPLORATORY AIM 4: TO EXAMINE IF BMI INFLUENCES THE RELATIONSHIP BETWEEN SELF-REPORT AND PERFORMANCE-BASED MEASURES OF PHYSICAL FUNCTION

It was hypothesized that there would be a difference in the relationship between the self-report measure and the performance-based measure based on BMI. Compared to those classified as normal weight and overweight, the hypothesis was that a greater percentage of individuals with obesity would inaccurately report ability. Furthermore, it was believed that the obese would under-report ability compared to those of normal weight.

This study demonstrated BMI had an impact on the relationship between self-report and performance-based measures of physical function. When BMI was added to regression models examining the ability of the self-report measure to predict walking performance, BMI attenuated the relationship between the measures by approximately 50% indicating a significant influence of BMI on association between perception and performance (Table 10). Moreover, when examining the relation of the self-report measure to performance in normal weight and overweight participants only, all performance measures were moderately to strongly related to self-reported function. However, this was not observed in the individuals with obesity. When the relation of self-report and performance-based measures was explored in the latter group, gait speed and chair rise were not related to self-reported functional ability (Table 11).

The influence of BMI on the association between the measures was also apparent when comparing self-reported walking ability to walking performance. A greater number of individuals with obesity performed differently than their report (Tables 12 and 13). In a previous study of older adults, it was found that those that under-reported their ability were more likely to be obese [20]. However, in the current study, individuals with obesity tended to both under and over-report their walking ability compared to their performance on the walking tests; indicating less accurate overall perception of ability compared to those that were normal weight and overweight.

The finding that individuals with obesity less accurately perceived their functional ability may be reflective of an increased effort to perform functional tasks in obese compared to those of normal weight. Individuals with obesity have been shown to expend more energy during walking than non-obese [138]. Hills and colleagues observed that obese individuals' heart rates averaged 70% of predicted maximal levels for self-selected walking speeds compared to 58% in those that were normal weight [139]. In addition, previous researchers have reported that obesity increases perceived exertion during walking [10, 140]. In the current study, individuals with obesity may have reported lower levels of physical functioning than they were capable due to increased effort and perceived exertion required to complete the task.

In addition, perception of ability in the obese group may have also been influenced by discomfort, pain, or symptoms associated with comorbid health conditions. In the current study, participants with obesity reported a greater number of co-morbid health conditions and as a result, may have experienced more symptoms related to health conditions during walking. Previous studies have reported that obese individuals report more discomfort and musculoskeletal pain during functional walking tests compared to lean counterparts [10].

Another explanation for the discrepancy in perception and ability in the obese could be related to physical activity level. This seems most plausible because women in the obese groups were less active than those in the normal weight and overweight groups. Furthermore, individuals with obesity tended to both under-report and over-report abilities. Having been less physically active, participants with obesity may not have had an accurate perception of their abilities. This finding is supported in previous studies that have shown that perception of walking ability was related to physical activity level [20, 141]. Data from the Women's Health and Aging Study support that women who perceive they have difficulty walking are less active than those who perceive less difficulty [141]. When implementing physical activity interventions, the factors associated with perception of difficulty walking, such as perceived effort and associated symptoms that interfere with walking, should to be addressed to improve adherence and participation.

5.9 LIMITATIONS AND FUTURE RESEARCH

This study is not without limitations that could impact the application of the observed results. The following limitations and recommendations should be considered for future research:

1) This study was cross-sectional in nature; thus, the direction of causality cannot be established. Longitudinal designs are necessary to examine the causal relationship between physical function and BMI. Furthermore, longitudinal designs are required to determine the predictive value of the measures for identifying incident mobility limitation and disability in adults that are overweight and obese.
2) The study compared self-report and performance-based measures at one time point; thus, it cannot be determined if the association between the measures is maintained with repeated measures. In addition, it cannot be determined how responsive the measures are to an intervention, such as a weight loss program. Future studies should implement self-report and performance-based measures of physical function at

multiple time points to determine the sensitivity of the measures to change in response an intervention.

3) This study did not take into account other lifestyle factors that may have influenced physical function such as current or former smoking, unhealthy diet, and alcohol use, all of which may have confounded the results. Future studies should consider controlling for lifestyle factors which have been shown to influence risk of functional limitation.
4) The performance-based measures used in this study did not cover all possible domains of physical function. For example, no measures of upper extremity function were employed. The inclusion of additional performance-based measures would provide more detail of the global deficits in physical function experienced in the obese.
5) Characteristics of the sample (gender, age, physical activity level) were controlled to decrease the potential for confounding variables to influence physical function. Thus, the findings of the current study cannot be generalized to populations that do not match the characteristics of those in the study.

5.10 CONCLUSION

The results of this study expand on the current evidence linking high BMI to limitations in physical function. High BMI had an adverse effect on common every-day activities such as walking, stair climbing, and crouching/stooping and kneeling, in adult women. Furthermore, individuals at the highest BMI levels demonstrated significant impairments in walking; classifying them as high risk for future adverse health events including falls, nursing home admission, disability and death based on previous studies in older adults [95]. The magnitude of functional limitations in the obese was striking considering the participants in the current study were apparently healthy, middle-aged women.

In this study, individuals classified as normal weight and overweight were similar in physical function, while individuals with obesity had greater impairments in physical function. Given the likelihood these individuals with obesity will progress from a pre-clinical stage to a more debilitated stage in the hierarchy of physical function, they may be an optimal target group for interventions to prevent future disability. Though the data are limited, there is evidence that behavioral weight loss interventions that incorporate diet and physical activity lead to improvements in physical function in adults with obesity [11, 100, 101, 105]. The majority of improvements have been found in activities such as walking and stair climbing ability; two functional tasks in which the current subjects were most impaired.

Self-report and performance-based measures of physical function were shown to contribute independent information to the description of physical function in adult women across the range of BMI categories. The self-report was able to identify perceived limitations in function while the performance-based measures portrayed actual ability. Given the impact of both dimensions on quality of life, it would be important to reflect changes in both perception and ability when assessing the efficacy of a weight loss intervention in improving physical function.

Compared to those that were normal weight and overweight, obese women less accurately depicted physical function abilities. The discrepancy between perception and ability may have resulted from greater perceived effort, the influence of symptoms such as pain, and/or lower physical activity level in the obese [10, 138, 140, 141]. These findings reinforce the need for a comprehensive set of measures to accurately describe physical function in this population.

APPENDIX A

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

1. Has a doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

   ☐ Yes
   ☐ No

2. Do you feel pain in your chest when you do physical activity?

   ☐ Yes
   ☐ No

3. In the past month, have you had chest pain when you were not doing physical activity?

   ☐ Yes
   ☐ No

4. Do you lose your balance because of dizziness or do you ever lose consciousness?

   ☐ Yes
   ☐ No

5. Do you have a bone or joint problem that could be made worse by a chan your physical activity?

   ☐ Yes
   ☐ No

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

   ☐ Yes
   ☐ No

7. Do you know of any other reason why you should not do physical activity?

   ☐ Yes
   ☐ No

Adapted from the 1994 revised version of the Physical Activity Readiness Questionnaire (PAR-Q and YOU). The PAR-Q and YOU is a pre-exercise screen owned by the Canadian Society for Exercise Physiology.

APPENDIX B

THE PHYSICAL FUNCTIONING INVENTORY

Instructions for the participant: "I am now going to ask you questions about whether you have difficulty doing specific activities in your daily life. I will also ask you if you have modified or changed the way that you do each activity so that you can continue to do it successfully. Please think about how you currently do each task and whether you are doing anything differently now compared to how you did it before. Modifications include the use of assistive devices, such as a cane or handrails, doing an activity more slowly, needing the help of another person, or any other change. Do you have any questions?"

A Do you have any difficulty (insert task here)? No (Go to E) Yes (Go to B)

B How much difficulty do you have (insert task here)? Some, a lot, unable to do by myself, don't know

C Do you need any assistive devices to (insert task here)? No, yes (changes in home set-up), yes (cane), yes (walker), yes (braces), yes (wheelchair), other, don't know

D Do you need the help of another person to (insert task here)? No, yes (supervision), yes (a little help), yes (a moderate amount of help), yes (a lot of help), yes, another person does it completely, don't know

E Have you modified the way you (insert task here) to continue to do it successfully? No (go to G), Yes, changed the way I do it for health reasons (go to F), yes changed the way I do it for non-health reasons (Go to G), don't know

F If Yes to E;
How have you modified or changed the way you do (insert task here)

G Have you changed how frequently you (insert task here)? No (if no to A, E, and G, go to next task), Yes-cut back, yes-given up, yes-do it more frequently, don't know

I For how long have you modified or had difficulty or been unable to do this activity? (Round answer to nearest year.)

J What are the main symptoms that cause you to modify, have difficulty, or prevent you from doing the activity? (See card 1)

K What are the main conditions that cause you to modify, have difficulty, or prevent you from doing the activity (See card 2)

Tasks, in order to be asked:

1. Walking up 10 steps?
2. Walking ½ mile (5-6 blocks)? (skip to 5 if no to 2 A)
3. Walking 1/3 of a block?
4. Walking around the house?
5. Stooping, crouching, or kneeling?
6. Performing moderate activities (golf, bowling, vacuuming, and gardening)
7. Performing strenuous activities (racquetball, jogging, heavy construction work, aerobic exercise)

What is the most strenuous activity that you do? ________________________________

Do you have any difficulty doing this activity? ___________________________________

Card 1 (For Question J)

Symptoms:

1. Shortness of breath
2. Diminished cardiovascular function/reduced endurance
3. Diminished muscle tone/strength
4. Chest pain/discomfort
5. Stiffness
6. Back pain
7. Calf pain with walking
8. Pain, other site ___________
9. Fear of pain/avoiding pain
10. Lightheadedness/dizziness
11. Weakness/fatigue
12. Difficulty walking
13. Unsteady on feet
14. Afraid of falling
15. Other: __________
16. Non-health reason, specify __________
17. No reason
18. Don't know

Card 2 (For Question K)

Conditions:

1. Heart disease
2. Atherosclerosis
3. Stroke
4. High blood pressure
5. Lung disease/breathing problems
6. Arthritis-hands, arms, shoulders
7. Arthritis-hips, knees, feet
8. Osteoporosis
9. Hip fracture
10. Hip replacement
11. Problem with back or neck
12. Paralysis
13. Eye disease
14. Cancer
15. Injury
16. Diabetes
17. Overweight
18. Incontinence
19. Memory problems
20. Mental illness
21. Other _________
22. Non-health reason _________
23. No reason
24. Don't know

APPENDIX C

THE LATE LIFE FUNCTION AND DISABILITY INSTRUMENT

Disability Questions:

How often do you?…(very often, often, once in a while, almost never, never)

To what extent do you feel limited in?…(not at all, a little, somewhat, a lot, completely)

D1. keep (keeping) in touch with others through letters, telephone, or e-mail
D2. visit (visiting) friends and family in their homes
D3. provide (providing) care or assistance to others
D4. take (taking) care of the inside of your home
D5. work (working) at a volunteer job outside your home
D6. take (taking) part in active recreation
D7. take (taking) care of household business, finances
D8. take (taking) care of your own health
D9. travel (traveling) out of town for at least an overnight stay
D10. take (taking) part in a regular fitness program
D11. invite (inviting) people into your home for a meal or entertainment
D12. go (going) out with others to public places such as restaurants or movies
D13. take (taking) care of your own personal care needs
D14. take (taking) part in organized social activities
D15. take (taking) care of local errands
D16. prepare (preparing) meals for yourself

Function Questions:

How much difficulty do you have?…(none, a little, some, quite a lot, cannot do)

F1. unscrewing the lid off a previously unopened jar without using any devices
F2. going up and down a flight of stairs inside, using a handrail
F3. putting on and taking off long pants (including managing fasteners)
F4. running half a mile or more
F5. using common utensils for preparing meals (e.g., can opener, potato peeler, or sharp knife)
F6. holding a full glass of water in one hand
F7. walking a mile, taking rests as necessary
F8. going up and down a flight of stairs outside, without using a handrail
F9. running a short distance, such as to catch a bus
F10. reaching overhead while standing, as if to pull a light cord
F11. sitting down in and standing up from a low, soft couch
F12. putting on and taking off a coat or jacket
F13. reaching behind your back as if to put a belt through a belt loop
F14. stepping up and down from a curb
F15. opening a heavy, outside door
F16. ripping open a package of snack food (e.g., cellophane wrapping on crackers) using your hands
F17. pouring from a large pitcher
F18. getting into and out of a car/taxi (sedan)
F19. hiking a couple of miles on uneven surfaces, including hills
F20. going up and down three flights of stairs inside, using a handrail
F21. picking up a kitchen chair and moving it, to clean
F22. using a step stool to reach into a high cabinet
F23. making a bed, including spreading and tucking in bed sheets
F24. carrying something in both arms while climbing a flight of stairs (e.g., laundry basket)
F25. bending over from a standing position to pick up a piece of clothing from the floor
F26. walking around one floor of your home, taking into consideration thresholds & doors

F27. getting up from the floor (as if you were lying on the ground)
F28. washing dishes, pots, and utensils by hand while standing at the sink
F29. walking several blocks
F30. taking a 1-mile, brisk walk without stopping to rest
F31. stepping on and off a bus
F32. walking on a slippery surface outdoors

APPENDIX D

TIMED CHAIR RISE

The participant will begin seated in a hard-backed chair. The participant will be asked to fold their arms across their chest.

The participant will be asked to stand up from the chair without using their arms one time.

If they are able to stand, they will be asked to stand up and sit down as quickly as possible five times in a row, with time measured at the final standing position at the end of the fifth stand. The participant should obtain full erect standing posture with knees extended on each repetition in order for the trial to count.

Timed Chair Rise (Single)

Single Chair Stand Script: This test will measure your ability to stand up and sit down in a chair.

(Demonstrate and explain the procedure). First, fold you arms across your chest and sit so that your feet are on the floor; then stand up keeping your arms folded across your chest.

Please stand up keeping your arms folded cross your chest.

If the participant cannot rise without using arms, say “okay, try to stand up using your arms.”

Single Chair Stand Test Questions:

1. Safe to stand without help	☐$_1$ Yes ☐$_0$ No
2. Was test attempted?	☐$_1$ Yes ☐$_0$ No (if Yes, answer 3) (if No, go to 4)
3. Results	
a. Participant stood without using arms	☐$_1$ Proceed to Repeated Chair Stands
b. Participant used arms to stand	☐$_2$ End Test
c. Test not completed	☐$_3$ End Test (if Yes, answer 4)
4. If participant did not attempt or failed:	
a. Tried but unable	☐$_1$
b. Participant could not stand unassisted	☐$_2$
c. Not attempted, you felt unsafe	☐$_3$
d. Not attempted, participant felt unsafe	☐$_4$
e. Participant unable to understand instructions	☐$_5$
f. Other Specify____	☐$_6$
g. Participant refused	☐$_7$

Timed Chair Rise (Repeated)

Repeated Chair Stand Test Script: We will now test your ability to stand up from a chair five times without using your arms.

(Demonstrate and explain the procedure): Please stand up straight as quickly as you can five times, without stopping in between. After standing up each time, sit down and then stand up again. Keep your arms folded across your chest. I will be timing you with a stopwatch.

When the participant is seated, say "Ready? Stand" and begin timing.
Count out loud as the participant arises each time, up to five times.

Stop the stopwatch when she has straightened up completely for the fifth time.

Also stop if:

- Participant uses her arms
- There are any concerns about participant's safety

Repeated Chair Stand Test Questions:

1. Safe to stand without help ☐$_1$ Yes ☐$_0$ No	
2. Was test attempted? ☐$_1$ Yes ☐$_0$ No (if Yes, answer 3) (if No, go to 4)	
3. Time to complete five stands *(only enter if participant completes 5 stands)* ☐☐.☐☐ seconds If participant failed test, answer 4.	
4. If participant did not attempt or failed:	
a. Tried but unable	☐$_1$
b. Participant could not stand unassisted	☐$_2$
c. Not attempted, you felt unsafe	☐$_3$
d. Not attempted, participant felt unsafe	☐$_4$
e. Participant unable to understand instructions	☐$_5$
f. Other Specify____	☐$_6$
g. Participant refused	☐$_7$

APPENDIX E

THE SIX-MINUTE WALK TEST

Equipment:

1. Level, straight hallway a minimum of 50 feet in length.
2. Traffic cones (2) to mark endpoints so that participant can walk around cones while adding minimal additional distance to the walk.
3. Stopwatch
4. Chair
5. Stethoscope and sphygmomanometer
6. Data collection sheets with system to record laps

Instructions for the Participant:

“This test will allow us to estimate your functional activity level. The test will run for a total of six minutes and during that time you are expected to cover as much distance as possible. If you need to stop, you may do so, and if I need to stop you for some reason, I will. Please tell me if you have any chest discomfort, dizziness, severe shortness of breath, unsteadiness, blurred vision, new or increasing arm, leg or back pain, numbness and/or tingling. You will walk back and forth in this hallway and you should pivot briskly around the cones and continue back the other way without hesitation. Please do not talk during the test except to let me know if you are having a problem or to answer specific questions.

Prior to and after the test I will be taking your heart rate and blood pressure. You may stop the test at any time. I ask that you give your best effort. This is not a pass/fail test. It is just a measurement of how far you can walk in six minutes. You should not run or jog during this test.

During the test, I will be asking you to give me a level on the Borg Rating of Perceived Exertion Scale (RPE scale). This scale is used to rate your overall effort during exercise. Perceived exertion means the inner feeling of exertion or effort you feel is required for you to do a certain exercise or activity. The numbers range from 6 to 20. A rating of “6” indicates the least amount of effort; a rating of “20” the maximum effort.”

Borg RPE Scale:

6	no exertion at all
7	extremely light
8	
9	very light
10	
11	light
12	
13	somewhat hard
14	
15	hard
16	
17	very hard
18	
19	extremely hard
20	maximal exertion

6-Minute Walk Test Data Collection

Vitals	**Baseline**	**Post-test**
Heart rate		
Blood Pressure		
Rate of Perceived Exertion		

Cross off number as each lap is completed:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

(# feet x number of laps covered) + distance of partial lap = total distance

(_____ (feet) x _____ (number of laps) + ______distance of partial lap = ______ total distance

Stopped before 6 minutes? If yes, record reason: ______________

Time when subject stopped: ____________

APPENDIX F

THE DUKE COMORBIDITY INDEX

1. Has your doctor ever told you have or have had ANGINA?
   - ☐ Yes
   - ☐ No
2. Has your doctor ever told you that you have or have had CONGESTIVE HEART FAILURE?
   - ☐ Yes
   - ☐ No
3. Has your doctor ever told you that you have or have had a HEART ATTACK?
   - ☐ Yes
   - ☐ No
4. Has our doctor ever told you that you have or have had PARKINSON DISEASE?
   - ☐ Yes
   - ☐ No
5. Has your doctor ever told you that you have or have had LUNG DISEASE, EMPHYSEMA, ASTHMA, or BRONCHITUS?
   - ☐ Yes
   - ☐ No
6. Has your doctor ever told you that you have or have had ARTHRITIS?
   - ☐ Yes
   - ☐ No
7. Has your doctor ever told you have you have or have had OSTEOPOROSIS?
   - ☐ Yes
   - ☐ No

8. Has your doctor ever told you that you have or have had BROKEN A BONE?
   - ☐ Yes
   - ☐ No
9. Has your doctor ever told you that you have or have had DEPRESSION, ANXIETY, OR AN EMOTIONAL PROBLEM?
   - ☐ Yes
   - ☐ No
10. Has your doctor ever told you that you have or have had a SLEEP PROBLEM (SUCH AS INSOMNIA OR NARCOLEPSY)?
    - ☐ Yes
    - ☐ No
11. Has your doctor ever told you that you have or have had CHRONIC PAIN SYNDROME?
    - ☐ Yes
    - ☐ No
12. Have you had a JOINT REPLACEMENT?
    - ☐ Yes
    - ☐ No
13. Has your doctor ever told you that you have or have had CANCER?
    - ☐ Yes
    - ☐ No
14. Has your doctor ever told you that you have or have had DIABETES?
    - ☐ Yes
    - ☐ No
15. Has your doctor ever told you that you have or have had CATARACTS?
    - ☐ Yes
    - ☐ No
16. Has your doctor ever told you that you have or have had a STROKE?
    - ☐ Yes
    - ☐ No
17. Has your doctor ever told you that you have or have had a HEARING PROBLEM?
    - ☐ Yes
    - ☐ No

APPENDIX G

MEAN SCALED SCORES FOR THE LATE LIFE FUNCTION AND DISABILITY INSTRUMENT

	Functioning	Disability Limitation	Disability Frequency
Severe Limitations	41.7	55.4	44.3
Moderate Limitations	53.2	63.5	49.5
Slight Limitations	65.6	73.8	53.6
No Limitations	75.6	82.5	58.1

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