THE RELATIONSHIP OF BODY COMPOSITION, MUSCLE FUNCTION, AND MUSCLE FIBER TYPE TO LOWER BODY PHYSICAL PERFORMANCE IN OVERWEIGHT AND OBESE OLDER ADULTS

BY

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LIST OF ABBREVIATIONS

μN – micro Newton
ADL – activity of daily living
ATP - Adenosine-triphosphate
BC – body composition
BMI – body mass index
BV – baseline visit
C – Celsius
CBC – complete blood cell count
cm – centimeters
CR – caloric restriction
CSA – cross - sectional area
CT - X-ray computed tomography
DXA – Dual Energy X-ray absorption
ECG – electrocardiogram
EGTA - ethylene glycol tetra acetic acid
FFM – fat-free mass
FM – fat mass
GE – General Electric
hr. – hour
kA – kilovolt
kg – kilogram
m – meter
mA – milliampere
MHC– Myosin Heavy Chain
mg – milligram
mg/dl – milligrams per deciliter
ml – milliliter
MM – Muscle Mass
mmHg – millimeters of mercury
MMSE – mini-mental state exam
Nm – Newton meter
NPR – Nottingham Power Rig
p - Probability
PAD – peripheral artery disease
pH – power of hydrogen
RCT – randomized controlled trial
RNA - Ribonucleic acid
ROM – range of motion
RT – resistance training
s – second
SD – standard deviation
SDS-PAGE - sodium dodecyl polyacrylamide gel electrophoresis
SPPB – Short Physical Performance Battery
SV – screening visit
TNFa - Tumor necrosis factor-alpha
vol/vol – volume per liter of solution
WHO – World Health Organization
wk – week
yr – year

ABSTRACT

Purpose: The purpose of this study was to investigate the relationship of body composition, muscle function and fiber type and lower body physical performance, in overweight and obese older adults.

Methods: 56 older (65-79 yrs), overweight and obese (BMI=27-35 kg/m^2) men and women were recruited. Each participant's body composition, muscle strength, muscle power and muscle quality were assessed. Muscle fiber type characteristics of the vastus lateralis were also measured. Lower body physical function was quantified by 400 m walk performance and the Short Physical Performance Battery. We examined associations between muscle function and fiber type with physical function.

Results: Muscle power explained the most variance in physical function in men (R^2 = .318). The most important predictor in females was muscle quality (R^2 = .206). The optimal regression model included fat mass, muscle mass, muscle strength, muscle power and muscle quality for both sexes (Males: p = .47, R^2 =.483), (Females: p = .46, R^2 = .383). Muscle fiber type explained < 5% of the variance for both sexes.

Discussion: These results suggest that the relationship of muscle function and lower body physical function is different between sexes. The most important predictor may be muscle power for men, and muscle quality for women. The impact of muscle fiber type is accounted for by muscle function. These differences in muscle function should be considered when prescribing exercise to improve physical function in older adults.

LITERATURE REVIEW

Significance of Aging & Obesity

Advances in medicine, science, and technology have ameliorated some of the challenges created by an aging society and have increased mean life expectancy. In fact, older adults (≥ 65 yrs. of age) are the fastest growing segment of all population cohorts in the United States. According to the Administration on Aging (AoA) in 2009, there were 39.6 million older adults, accounting for 12.6% of the population. The AoA also estimates that by 2030 there will be 72.1 million older adults; a growth of 19% since the year 2000. Many age-related health declines place a serious burden on the health care system. It is estimated that $592 billion dollars will be spent on Medicare, by 2023 spending is projected to double ($1.1 trillion)[1].

Older adults are at greater risk of developing significant health issues, particularly chronic diseases and disability. In 2010, 37% of the older adults reported some form of disability. Disability is frequently associated with mobility limitations. Among adults 85 or older, 62% of women and 46% of men report some mobility limitation[2]. Mobility is a strong predictor of physical function and it plays a critical role in the path to disablement[3]. People with mobility limitations are often unable to function independently. Therefore, limitations in mobility associated with aging put a serious burden on the health care system. In 2004, $135 billion was spent on long term care for older adults[4].

Prevalence of Overweight & Obesity in Older Adults

Although it is understood to be an imperfect measure, body mass index remains the most common assessment used to estimate body "fatness"[5]. It is the of a person's height in meters squared and body mass in kilograms (kg/m^2). and obesity are defined as an unhealthy excess of fat mass (FM). Overweight and obesity are defined as having a BMI of ≥25-29.9 $kg \cdot m^2$ and ≥30 $kg \cdot m^2$, respectively[6]. Among older adults, estimates suggest that 72.8% of older adults are overweight; while 37.8% are obese[7]. Because both the number of older adults and the percentage of older adults with excess FM have increased, this cohort contributes significantly to the rate of obesity in the entire population[8].

Aging, Obesity & Chronic Disease

Throughout the 20th century, the leading causes of death have shifted from infectious disease to chronic and degenerative illnesses, many of which relate to obesity. There is an association between obesity and mortality, with increasing FM leading to higher mortality[9-11]. Interestingly, divergent literature has suggested that as age increases adults with excess FM have a decreased relative risk of death[12]. As a result it has been postulated that excess FM maybe less harmful in the elderly, compared to younger populations. However, many studies fail to address factors such as, smoking status, survivor biases, and length of follow-up and underlying diseases[13,14]. Regardless, it is apparent that excess FM and aging are independent risk factors for disease. Among Medicare recipients 82% have at least one chronic condition and older adults are more likely to have two or more chronic conditions[4]. The risk of developing a chronic disease from

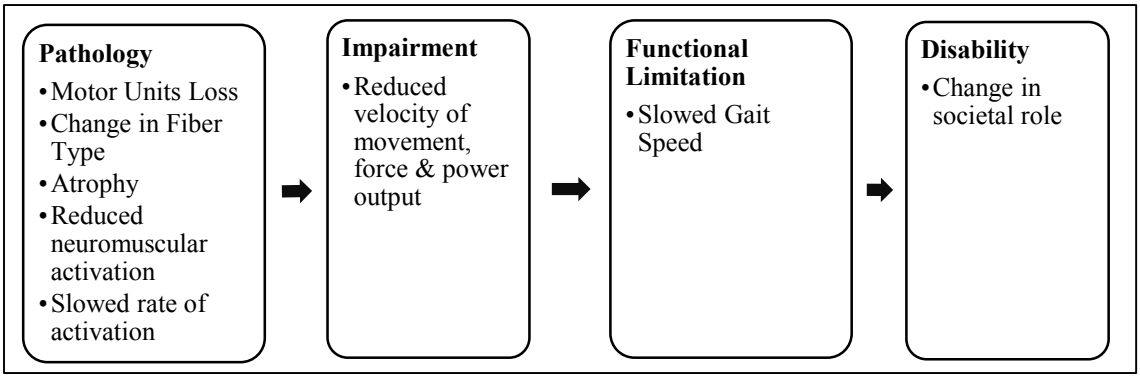
obesity (e.g., diabetes mellitus[15], hypertension[16], dyslipidemia[17], osteoarthritis[18,19], pulmonary abnormalities[20], and certain cancers[21]) also increases with age. Furthermore, Furthermore, the longer a person has excess fat the greater the risk of disease[22]. As a result, chronic diseases are more prevalent among overweight and obese older adults[22,23].

Disablement Models

When investigating older adult populations an understanding of the process which leads to disability is pivotal[24]. In older adults, complications from chronic disease and comorbidities, collectively create multiply factors causing disability[22].

In 1965, sociologist Saad Nagi proposed a disablement model[25]. It describes disability as a gap between a person's physical capabilities and demands created by their social and physical environment[25]. Nagi's model describes a disablement pathway establishing criteria which distinguish differences in 3 inter-related concepts that are sequential precursors to disability: active pathology, impairment, and functional limitation[25]. Nagi's model can be used as a foundation to describe the effects the age-related decline in muscle function can have on physical function (Figure 1). Verbrugge and Jette expanded on Nagi's model to include the influence of both intra- and extra-individual factors on the progression of disablement[25]. These additions help to explain how individual and environmental conditions alter the disablement process[26].

Figure 1. Nagi's Model of Disablement



Physical Disability

Throughout the aging process, physiological changes occur that can create pathologies. Depending on their complexity, pathologies can create impairments. Of great importance to physical disability are impairments related to muscle function. A physical function limitation is a restriction in performing fundamental physical actions (i.e. walking, lifting) used in daily life by one's age-sex group. Ultimately if a person's physical function limitation creates a difficulty doing activities in any domain of life, it is considered a disability[25].

In 2010, almost 50% of older adults in the United States reported having some type of disability. The prevalence of disability drastically increases with age, illustrated in Table 1. Obesity plays a major role in the process of disablement as excess body weight inhibits an older adult's ability to ambulate, perform activities of daily living (ADLs), and impairs overall physical function[27-29].

Obesity is a predictor of current physical function, functional status and future disability in older adults[27,30]. Older adults with excess FM report having diminished physical function, compared to their lean counterparts. A 3-unit

increase in BMI has shown to reduce physical performance test scores 1-point[27,30]. In addition, older adults who are obese are more likely to develop functional declines, leading to disability[27,31]. Given the negative health consequences associated with aging and obesity, it is evident that the age related declines in physical function are likely worsened in obese older adults[8].

The most prevalent functional limitations reported by older adults are difficulty with heavy housework and walking. Additionally, these specific limitations are the least likely to resolve[32]. In 2010, among older adults, 39.4% reported mobility difficulties and 34.4% reported them as severe[2]. Testing mobility and functional status is important in the diagnosis, treatment and rehabilitation of functional limitations.

Table 1. Disability in America

Age Range (yrs)	Some Type of Disability (%)
65-69	35%
70-74	42.6%
75-79	53.6%
≥80	70.5%
Adapted from Brault, 2012	

Mobility

Mobility is defined as the ability to walk, climb stairs, transfer body weight, and generate moderate walking speed. Many activities required for independent life depend on mobility ability[8]. The combination of individual factors and the environmental demands determine the severity of a mobility limitation[26]. Mobility limitations affecting individual independence potentially decrease a person's quality of life, while at the same time creating hardship for caregivers and family members. Among older adults in 2010, 15.2 million (≈ 40%) reported difficulty with ambulatory activities and 11.2 million reported severe difficulty[33].

Activities that involve mobility such as; traveling, self-care, using the bathroom, and general maneuvering are more difficult for older adults with excess FM. Obese older adults perform significantly worse on mobility assessments, compared to older adults with normal body mass[8,31].

The Age-related Changes to Body Composition & Its Implication

The physiological process of aging that occurs naturally affects all systems in the human body and the muscle system is no exception. Because the muscle system accounts for a large portion of a person's body mass and is vital to our survival, it is of great interest. The function of skeletal muscle is based on its composition, and the ability to generate force and power. As such, skeletal muscle function is affected by a person's body composition, muscle strength, muscle quality and muscle power. In general, each of these components is negatively impacted by the aging process and declines in these components of muscle function can potentially lead to serious health problems[34-40].

Body Composition

Body composition (BC) is mostly determined by muscle mass (MM) and fat-mass (FM). FM gradually increases throughout adulthood, peaking in the 6th or 7th decade. Subsequently, septuagenarians experience declines in both MM and FM[22]. Moreover, there is a greater relative increase in visceral fat, compared to total body fat, ultimately elevating the amount of central adiposity[22]. Conceivably, excessive central adiposity may adversely affect joint mechanics, decrease postural stability, and increase the risk for functional impairment[8]. Cross-sectional data show a higher prevalence of disability in older persons with higher FM, even

in those with normal amounts of MM[22]. In longitudinal studies a greater decline in function and earlier onset of disability in seen in more obese elders. The association association between adiposity and function is not entirely explained by age, physical activity, or chronic disease[41]. Thus, fat itself may affect the molecular, morphologic and metabolic properties of muscle that lead to loss of function.

Unlike FM, MM peaks at ≈30 years of age and then progressively declines. Although the rate of decline appears to be relatively slow[31], it is progressive; throughout adulthood (20-70 yrs), MM decreases by up to 40%. A greater relative decline in peripheral MM occurs, compared to central MM. Moreover, men typically experience greater age-related decreases in MM (≈15%), compared to women (≈ 10%)[42]. Although the decline is less among women, they begin with less MM. Therefore, it is thought that the age-related decline in MM is a greater concern for women. Regardless, older adults with low MM are at an increased risk of functional decline and disability[43-46]. MM describes a significant amount of the variance in muscle strength; older adults with low MM are typically weaker[41,47].

Sarcopenia

Sarcopenia describes the progressive decline in skeletal muscle mass. The word is derived from the Greek words ‘sarx’ or flesh and ‘penia’ or loss. There is literature suggesting the age-related decline in strength is explained by declines in muscle mass. In addition, muscle strength has a marked effect on physical function. In fact, the loss of strength is included in some definitions of sarcopenia. Regardless, both muscle mass and strength decline with age, increasing the prevalence of sarcopenia, by all definitions, in older populations[48].

Older individuals who develop sarcopenia experience adverse physiological changes that result in other chronic diseases. For example, sarcopenia results in less mechanical stress on the bones leading to reduced bone mineral density[49]. Subsequently, persons with sarcopenia are at an increased risk of osteoporosis[39], having a fall, bone fractures, impaired ability to perform ADLs, mobility disability and death[46]. Moreover, loss of muscle mass decreases immune system functioning thereby reducing performance of the recovery process from injury or surgery[49].

Given that recent literature suggests the age-related decline in muscle strength cannot be explained solely by the decline in muscle mass[50], it is now recognized that muscle strength should be assessed in addition to any measure of body composition in order to better understand the role of skeletal muscle in functional decline and disability.

The Age-related Changes to Muscle Function & Its Implications

Muscle Strength

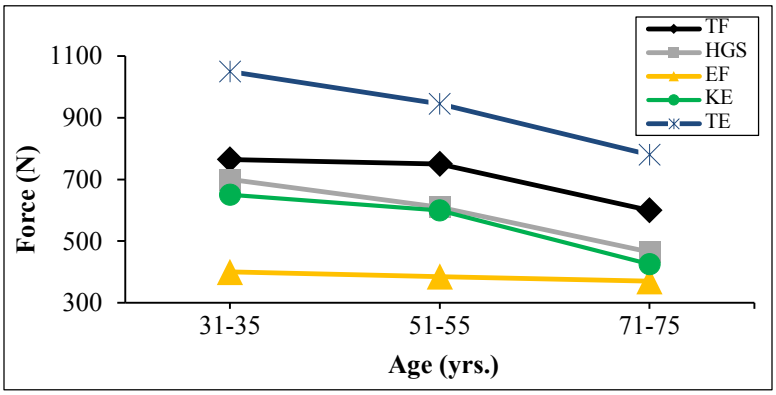
Muscle strength is the ability of a muscle or muscle group to exert maximal force at a specific velocity during a contraction[51]. Coinciding with MM, muscle strength peaks between the ages of 20-30 years[52]. In the absence of resistance training (RT), muscle strength remains unchanged or decreases slightly for 20 years. Afterwards, a steeper decline in maximal strength begins in both sex, especially with the onset of the sixth decade.

From 30 to 80 yrs of age the decrease in maximal strength can as much as 30-40%[52-56], although the rate of decline varies depending on the muscle group

and action (Figure 2.)[53]. Lower body muscle groups typically have greater losses in strength, compared to upper body musculature. One reason suggested for this observation is that older adults decrease the use of lower limb muscles more compared to the upper body muscle groups[52].

The Baltimore Longitudinal Study of Aging assessed muscular strength in 654 subjects, 346 men and 308 women between 20-93 years of age. Lindle and colleagues used the data obtained from the Baltimore study to show that both men and women experience age-related declines in isometric, concentric, and eccentric knee extensor peak torque with aging[34]. These declines effect physical function and jeopardize the health and well-being of older adults.

Figure 2. Strength of Muscle Action



Muscle Fiber Type

Skeletal muscle fibers are primarily categorized by the metabolic pathway used to generate Adenosine triphosphate (ATP) and the contraction speed. There are three fiber types: type I, slow-twitch oxidative fibers; type IIa, fast-twitch oxidative fibers; and type IIx, fast-twitch glycolytic fibers[57-59].

Type I fibers have a largest number of mitochondria and greatest capillary density, providing adequate blood flow and oxygen to keep up with the relatively slow

rate of ATP breakdown[60]. Because of this, these fibers are difficult to fatigue and are well suited for prolonged, low-intensity activities (i.e. walking). Type I fibers are the smallest in diameter, have relatively smaller force output and slower contractile velocities[58,59].

Type IIa muscle fibers are suited for aerobic and anaerobic tasks because of their fast contraction times and quality blood supply (i.e. climbing stairs). These fibers are considered intermediate between Type I and IIx. These fibers will fatigue when task intensities cause the rate of ATP splitting to exceed the rate ATP can be supplied[58,59,61].

Type IIx muscle fibers have very few capillaries within their vicinity, limiting their blood supply. In order to produce ATP they predominantly rely on glycolytic mechanisms for ATP production. These fibers produce ATP at a fast rate, but the high rate of ATP splitting rapidly depletes glycogen. Type IIx fibers are suited for tasks that require rapid force production for a small amount of time (e.g. rising from a chair)[58,59,61].

The morphological changes to aging skeletal muscle are an important contributor to the age-related changes in strength. It is widely accepted that aging results in a reduction of type I and II fiber size, with type II being far greater[57]. However, it should be noted that studies supporting this claim often use muscle biopsies from the vastus lateralis of the quadriceps muscle group (Table 2)[62-67].

In addition to the reduction in fiber size there is a reduction in muscle volume muscle volume (MV), specifically a reduction in muscle contractile tissue[57]. This atrophy of skeletal muscle is the result of both the loss of fibers and

a reduction in fiber size. Given that decrease in fiber number mirrors the decrease in total decrease of MM, number of fibers predominantly determines muscle CSA. This suggests that reduction of fibers is the primary reason for age-related reduced area of the vastus lateralis muscle[68].

Table 2. Decrease in Size of Muscle Fiber Types

Reference	Muscle	Sex	Age (yrs)	Type I	Type II
Tomonaga 1977	VL	M/F	60-90+	-7%	-52%
Larsson et al., 1988	VL	M	22-65	-1%	-25%
Scelsi et al., 1980	VL	M/F	65-89	-7%	-24%
Essén-Gustavsson & Borges 1986	VL	M	20-70	-15%	-19%
Lexell & Taylor, 1991	VL	F	20-70	-25%	-45%
Jakobsson et al., 1990	VL	M	19-86	-6%	-35%

VL=Vastus Lateralis of the quadriceps

The age-related decrease in fiber number is postulated to be more prevalent in type II fibers. At the same time, studies have shown a slight increase in the percentage of type I fibers. Taken together this suggests that the proportion of muscle fiber type is altered during aging[62-67]. When the proportion and mean area are combined to represent the relative area of type II fibers, the muscle CSA occupied by type II fibers is significantly reduced during aging, compared to type I fibers. Therefore, the age-related changes of muscle fiber types are one mechanism for the age-related decline in muscle strength. Evaluating the properties of muscle fibers should be considered in gerontology research and even certain clinical assessments concerning muscle strength.

Assessing Muscle Strength in Older Adults

Testing of muscle strength occurs in a variety of settings, including sports, physical education, ergonomic, and clinical practice[69]. Assessments of strength can focus on isometric, concentric, or eccentric contractions. The results of muscle strength testing can be used to create normative values, distinguish differences in performance, evaluate

results from surgery or therapy, and assess functional performance[70]. Specific to older adults, the evaluation of muscle performance has become an important assessment in epidemiologic studies and clinical trials that are focused on physical function and mobility[71].

The most common methods of evaluating muscle strength in older adults are handgrip dynamometry, 1 repetition maximum (RM) testing and isokinetic dynamometry[71]. A handgrip dynamometer is the most commonly used device to obtain strength data on large samples and is reported to be accurate, reliable, portable, easy to administer, and inexpensive[72]. However, this measure has reduced significance to the functional status of older adults because it measures force production during static movements of the upper body. Most functional tasks important for mobility require dynamic movements of the lower body. As such, measures of lower body muscle strength that are dynamic are likely to be better indicators of functional status. A 1 RM is the heaviest weight that a person can lift concentrically throughout a complete range of movement and it is commonly used in the elderly[70]. Functional tasks that require moving heavy loads are similar to 1-RM tests. However, isokinetic assessment of muscle strength and power is considered the gold standard.

Isokinetic dynamometry

For over 40 years, isokinetics has been used for testing muscle performance. In the past twenty years, isokinetic dynamometers have been used more frequently in the assessment of muscle strength, as their availability has increased[73-75]. Most dynamometers allow measurements of concentric and

eccentric contractions. Data can be obtained throughout the full range of movement providing angle specific data. Furthermore, it provides the ability to identify pre-existing weaknesses[75]. When compared to 1 RM testing, isokinetic dynamometry has an increased accuracy of profiling muscle strength and better isolation of neuromuscular function[76,77]. As a result, it is generally accepted as the gold standard is muscle strength testing in all age groups[78].

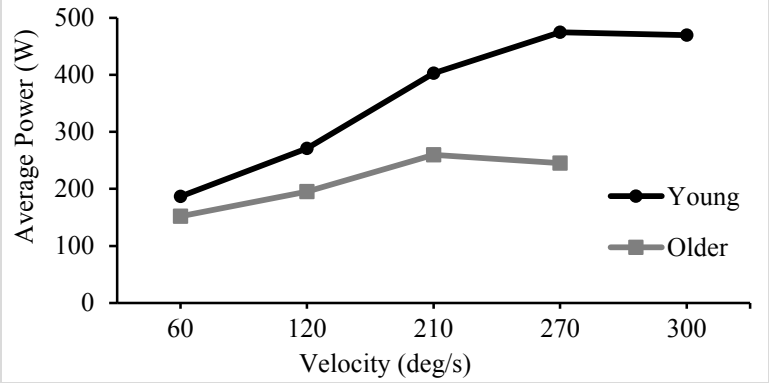
A person's muscle strength can be classified based on their results from isokinetic testing. Given that testing can be performed bilaterally, weakness patterns can be identified. Furthermore, ratios for agonist/antagonist muscle groups like the quadriceps/hamstrings can be evaluated for imbalances[75]. Isokinetic data can be compared or establish normative data for specific population cohorts[71].

The relationship between joint torque and angular velocity is commonly used to quantify dynamic muscle strength[79]. This measurement is similar to the force-velocity relationship in isolated muscle[50]. Although torque production is important to functional capacity, the speed of muscle contractions may be a better determinate. The use of isokinetic dynamometry allows for the measurement of the time needed to reach a set target force, which is the rate of force production. Often studies use a range of target velocities from 60 to 400 $°\cdot s^{-1}$ to address this issue. Some older adults however, are unable to reach target velocities, typically those > $270°\cdot s^{-1}$, although they may be lower[50]. The age-related changes to the muscle morphology described above inhibit the speed of muscle contractions. This slowing of muscle contraction speed has been associated with impairments that can lead to physical disability.

Muscle Power

Muscle power is the product of force and muscle contraction velocity. Muscle power declines earlier and at a higher rate than muscle strength in later life[80]. The results in Figure 3 illustrate a force time curve of a bilateral knee extension across age. Because force and contraction velocity are both components of muscle power, a reduction in either parameter will contribute to reduced power output. Mobility tasks like walking and ascending stairs are dependent on both the force and speed of muscle contractions. Furthermore, the maximal force output of a muscle is typically not required for a person to complete most mobility tasks. Bassey et al. investigated the contribution of muscle power to different physical function tasks among institutionalized older adults considered frail. They concluded that performing chair rises, climbing stairs, and achieving a moderate gait speed were all associated with leg extensor power[81].

Figure 3. Muscle Power: Knee Extension

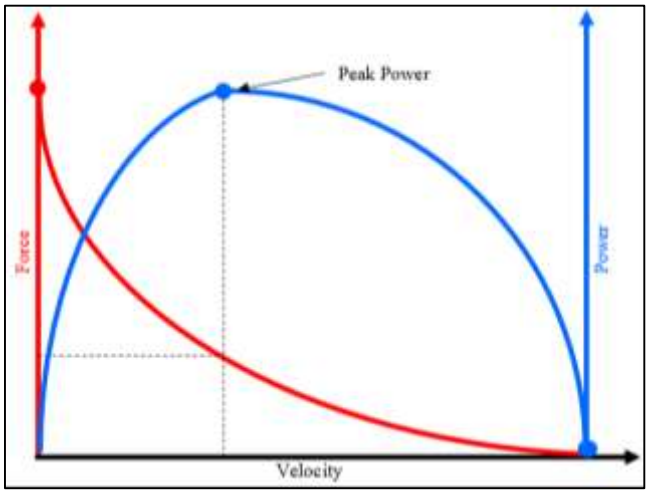


Muscle power may be a better determinate of physical function ability than muscle strength[82]. Foldvari and colleagues examined the association between muscle power and muscle strength with functional independence among community dwelling elderly women with disability. Peak muscle power (PMP) (R^2 = .221) was superior to muscle strength (R^2 = .189) in determining functional status[83]. Moreover, even after

accounting for confounding variables, PMP independently predicted functional dependency. These studies used self-report to assess physical function and disability status. Bean and colleagues investigated the role of muscle power and strength in community-dwelling older adults, using the SPPB to assess mobility status. Compared to muscle strength, leg power explained more variance (2-8% more) for each measure of the SPPB. At the same time, muscle power has shown to be a more influential factor of mobility status than muscle strength. Within a cohort of 1032 older adults, those with low muscle power output had twice the risk of significant mobility impairment than individuals with low muscle strength[84]. This suggests that muscle power is a proximal determinant of physical function status and perhaps more so than muscle strength.

Muscle power can be determined for a single body movement, a discrete sequence of movements, or repetitive movements[70,85,86]. Because power is the product of torque and angular velocity, assessments of muscle power often measure these variables. When assessed over a range of external resistances (40-90% of 1-RM), peak muscle power is produced at approximately 70% of the 1-RM. The maximal contraction velocity, force, and power output is typically found at 40% 90% and 70% 1-RM, respectively[70] (Figure 4). Each of these can be assessed by an isokinetic dynamometer capable of measuring force dynamically, while simultaneously measuring the velocity of movement.

Figure 4. Force-Velocity Relationship



Muscle Quality

Muscle quality has been identified as a relevant indicator of overall functional capacity of skeletal muscle[37]. Muscle quality is the quotient of force production and MM. The higher levels of FM in older adults partially accounts for the decline in muscle quality with age[30,87] suggesting that adipose tissue may have deleterious effects on muscle contractile ability[36]. Importantly, exercise studies show that improvements in muscle strength and quality are greater than increases in muscle mass[36,37,88-90] suggesting that factors other than muscle mass are responsible for exercise-induced strength increases. Even in very old persons, muscle quality increases in response to a RT intervention, although it is lower in obese persons and strength responses to RT may be blunted in obese individuals[40,76,86,91].

PURPOSE OF THE STUDY

The purpose of this study was to investigate the relationship of body composition, muscle function and muscle fiber type to lower body physical performance of the lower body, in overweight and obese older adults. Muscle function was assessed through muscle strength, muscle power, and muscle quality. Muscle fiber type of the vastus lateralis was measured using muscle biopsy. Muscle strength was assessed as peak torque at $60°\cdot s^{-1}$ during knee extension. Muscle power was assessed as the product of peak torque and peak velocity at $240°\cdot s^{-1}$ during knee extension. Muscle quality was calculated as the ratio of knee extensor strength to muscle mass, measured by Dual energy X-ray absorptiometry (DXA) and the thigh muscle volume (MV), measured by computed tomography (CT) scan. Analysis of muscle biopsies were used to identify fiber type. To assess lower body physical function we measured gait speed, balance and performance on a chair rise task, using the Short Physical Performance Battery (SPPB) and the 400 m walk test done at a fast pace.

Hypotheses

We hypothesize that:

1. There will be a direct relationship between measured muscle function and measured lower body physical performance.

2. Each component of muscle function (muscle strength, muscle power and muscle quality) will have a direct relationship with lower body physical performance, independent of the other components.

3. There will be a direct relationship between percentage of type II muscle fibers and lower body physical performance.

4. Muscle Power will be the most dominate predictor of lower body physical performance.

METHODS

Background

The Improving Muscle for Functional Independence Trial (I'M FIT) is a 5 month randomized, clinical trial (RCT) in 126 older (65-79 yrs), overweight and obese (BMI=27-35 kg/m^2) men and women. Participants were randomized to a resistance training (RT) intervention or a RT training + caloric restriction (CR) intervention. The primary outcomes were change in muscle function, assessed by knee extensor muscle quality, leg press muscle power, and physical function assessed by the Short Physical Performance Battery (SPPB) score. Additionally, changes in these functional outcomes were examined for associations with *in vivo* characteristics of skeletal muscle (intra-myocellular lipid, single-fiber contractile force/power, and gene and protein expression of Interleukin-6 [IL-6] and Tumor necrosis factor-alpha [TNFa]), as well as with systemic and adipose tissue indicators of inflammation (gene expression and release of adiponectin, IL-6 and TNFa).

In this thesis, we focused on the baseline data from participants that had muscle biopsies. The aim of this thesis was to investigate the relationship of body composition, muscle function, and muscle fiber type to lower body physical performance in overweight and obese older adults.

Procedures

Measures

All baseline assessments were conducted during four visits (1 screening visit, 3 baseline visits, Table 3). The screening visit (SV) was conducted in the

morning following a 12-hr fast for the purpose of measuring fasting glucose, lipids, a complete blood cell count (CBC) and metabolic panel. BV2 and BV3 were conducted in the early morning after a 12-hr fast (Table 3).

Table 3. Assessment Timeline

Visit Code (Week #)	SV (wk 1)	SV1 (wk 2)	BV2 (wk 3)	BV3 (wk 4)
Informed consent, review inclusion/exclusion criteria, demographics, medication review, physical exam	X			
Biodex familiarization (muscle strength/power) & lower body physical function (SPPB)		X		
Biodex Testing			X	
Muscle biopsies				X

Participants

Participants were recruited from the Piedmont Triad area. All individuals who responded to recruitment were initially screened via telephone to determine general eligibility. They were asked about their age, weight, height, current physical activity level, body weight changes in the past year, smoking history, medical history, and current medications. Individuals who remained eligible after the phone screening were scheduled for an in-person screening visit (SV) at the Geriatric Research Center clinic in the Sticht Center on Aging. Before any data collection, participants provided written informed consent to participate and completed a Health Insurance Portability and Accountability Act authorization form in accordance with the Wake Forest University Internal Review Board policy. At the SV visit, demographic data (age, sex, race, socio-economic status, and education) were collected. Height and body mass were measured and used to calculate body mass index (BMI). If the participant met the BMI inclusion criteria, the SPPB was administered. Individuals were considered to have poor lower body

performance if their scored ranged between ≥4- ≤9. Screening for cognitive impairment was done using the Mini Mental State Exam[92] Physical activity level was assessed using the Physical Activity Scale for the Elderly[80]. A medical history review and exam was done which included an electrocardiogram (ECG), blood pressure check, comprehensive review of medications (in particular; anti-inflammatory agents, protein supplements, sex steroids or corticosteroids), fasting blood draw for a metabolic panel and blood cell count. Any individuals with abnormal test results at this screening visit were referred to their physician for evaluation.

All participants were required to meet the inclusion/exclusion criteria (Table 4). These selection criteria eliminated participants with conditions that may have compromised their ability to complete a RT program or affected the physiological response to RT and/or CR.

Table 4. Inclusion & Exclusion Criteria

Inclusion	Exclusion
Age=65-79 years	Weight loss/gain (±5%) past 6 mth
BMI=30-34.9 kg/m^2	Body mass >140 kg (DXA limit)
Evidence of impaired lower body function	SPPB ≥4 or ≤9
Sedentary for past 6 mth (<20 min; 2 d/wk of resistance or aerobic exercise)	Exercise >2 d/wk; 20 mins/day
Normal cognitive function (MMSE >21)	Regular smoker (>1 cigarette/day) within past year
Fasting blood glucose <125 mg/dl	Insulin dependent or uncontrolled diabetes
No contraindications for participation in weight loss or exercise (e.g., severe arthritis or musculoskeletal disorders)	Uncontrolled hypertension (BP>160/90 mmHg) High TG (TG>400 mg/dl)
Able to provide own transportation to study visits and intervention	Serious conduction disorder (e.g., 3rd degree heart block), uncontrolled arrhythmia, or new Q waves or ST-segment depressions (>3 mm) on ECG
Approved for participation by Medical Director	Past or current ischemic heart disease, uncontrolled angina, heart failure, PAD, stroke, chronic respiratory disease, endocrine or metabolic disease, neurological or hematological disease
Not involved in any other research study	Cancer requiring treatment in past year, (except non-melanoma skin cancers)
No dependence on walker/cane	Clinically evident edema or anemia
Willing to provide informed consent	Regular use of any medications that could influence study variables (growth/steroid hormones, including estrogen replacement, anti-inflammatory)

Body Composition

Dual-Energy X-ray Absorptiometry (DXA) measured body composition. Daily quality control scans were obtained with Hologic's phantom. If results were more than two standard deviations (SD) from baseline, we repeated the phantom scan. If both scans were > 2SDs from baseline, we did not measure any more individuals and had the scanner serviced. Each week, the daily phantom data were analyzed to detect drifts. If changes in software or the machine occurred, the scanner was calibrated with the new software to ensure consistency. Every scan was examined to evaluate for proper patient positioning and analysis, and reanalysis or rescanning was performed if necessary.

An X-ray computed tomography (CT) scan (LightSpeed PlusTM, General Electric Medical Systems, Milwaukee) of the thigh was performed to assess thigh muscle volume (MV) and inter-muscular adipose tissue. The scan parameters were set at 120 kV and 350 mA. Approximately 50 scans were obtained covering the entire femur from the hip through the knee joint. Quantitative measures of muscle and adipose tissue, as well as CT attenuation values, were obtained with the GE Healthcare, Advantage Windows 4.2 Volume Viewer (Waukesha, WI). The same CT reading technician analyzed all scans. The total volume of non-adipose, non-bone tissue within the deep facials plane was used as a measure of muscle volume (MV) (cm^3). The average value across both legs was used in data analyses. Each segmented image was reviewed and, if needed, was edited to correct any misclassified pixels. This approach has a coefficient of variation < 0.5%. Daily calibration scans were obtained according to the manufacturer's

recommendations. Every 2 weeks, scans of a CT phantom were performed. If the individual phantom readings were more than 3% of the mean value, field engineers engineers serviced the CT scanner.

Muscle Function

Muscle Strength

Maximal knee extensor strength was measured using a Biodex dynamometer at $60°•s^{-1}$. Muscular strength was quantified as peak torque values and expressed in Newton-meters (Nm). A familiarization session (BV1) preceded the baseline session (BV2) to accommodate learning effects. These two sessions took place 5-7 days apart during a similar time on both days. Testing was conducted on the right and left legs, unless contraindicated (Table 5). The test-retest reliability of knee extensor maximal voluntary contraction is high among older adults[77,86,93-96]. Furthermore, studies of electrical stimulation superimposed on a maximal voluntary contraction have shown no additional torque production with stimulation in older men and women, suggesting that a maximal voluntary effort is a valid measure of muscle strength in this population.

Testing the quadriceps using a dynamometer is safe and well tolerated by the majority of older adults. However, injury may occur in people with knee joint pathology or when the machine is not operated correctly. To minimize the risk of injury during testing, flexion (towards) and extension (away) stops were in place throughout testing. Participants held a stop button during each session, which would stop the lever from moving. This allowed them to stop at any point if they were in excessive pain or discomfort because of the protocol. At each session, individual records were taken regarding information about machine settings and clinical notes. Furthermore, testers

checked for contraindications to testing, listed in Table 3 that may have increased the risk of an adverse event.

Table 5. Contraindications for Biodex Testing

Contraindication	Criteria	Assessment
Blood Pressure	>199 SBP or >109 DBP mm Hg	Sphygmomanometer
Cerebral Aneurysm	History of aneurysm	Self-Report of PD
Cerebral Hemorrhage	≤6-months	Self-Report of PD
Knee Replacement*	History of Replacement	SR
Knee Pain[£]	Trouble with flex/ext	Manual Test

PD = Physician diagnosed

Prior to every session, the dynamometer was initialized using the procedures provided by the manufacturer. Prior to testing, participants performed a 5-minute walking warm-up; afterwards their preferred leg was determined by whichever leg they used to kick a tennis ball. To standardize body position among participants, the following parameters were used. Participants sat upright in the dynamometer chair with the back at an 85° angle, to form a 90° at the participant's hip and knees. Two straps originating above each shoulder, then going diagonally over the participant's chest and inserting above the hip stabilized the torso. A strap that ran from the medial to lateral side of the thigh secured the thigh of the tested leg. The untested leg for each trial was unrestricted and unsupported. Participants were instructed to place their hands on the chest straps. This was to minimize the use of any upper body musculature during the test. The dynamometer lever arm was positioned 2 cm proximal to the anterior ankle crease. The lateral femoral condyle was aligned with the axis of rotation of the dynamometer. The positioning of the participant is illustrated in Figure 5.

Figure 5. Biodex Testing Positioning

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The range of motion was individually determined by approximating 90° flexion (towards) and 60° extension (away), for each participant. Gravity correction, for each participant, was done by weighing the limb at 60° of knee extension. To prevent unnecessary strain on the knee joint, ROM was restricted by angles of 90° flexion and 60° extension (assessed at BV1). The Biodex setup parameters were recorded at BV1 and used at BV2. The dynamometer was calibrated every two weeks using the supplied weight and following the manufacturer's specifications.

After body position was established, participants completed a standardized 5 minute warm-up on the dynamometer, involving 6-8 passive repetitions followed by three submaximal contractions (50-65% of maximum) at both $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$. Muscle strength data were collected during BV2. Each participant performed two trials for the right leg and two for the left. Every set consisted of four continuous maximal voluntary extension-flexion contractions. The first trial for each leg was performed at $60°\cdot s^{-1}$, followed by $240°\cdot s^{-1}$. The first repetition's extension component and the fourth repetition's flexion component for each trial were not included in data analyses. The participant was verbally instructed to push and pull as fast and as hard as possible

through the full available range of motion. Verbal encouragement was standardized for each participant in the following format: "push, push, push" during extension and "pull, pull, pull" during flexion. Visual feedback from the computer monitor was not shown to participants at any point. The right leg was tested first, unless contraindicated (Table 5).

Muscle Quality

Muscle quality was calculated as the ratio of knee extensor strength to muscle mass assessed by DXA (Nm/kg leg lean mass).

Muscle Power

Maximal knee extensor power was measured using a Biodex dynamometer at $240°\cdot s^{-1}$. Muscular power was quantified as the product of peak torque and the velocity at that respective peak torque. Power is defined as the amount of work per unit time, measured in Watts or Nm/sec. This device is can measure unilateral and bilateral leg extensor power[85], which is needed for many basic activities in daily life such as walking or rising from a seated position[37,87,90,97]. Leg extensor power has been shown to correlate well with functional measures, such as chair-rising speed, stair-climbing speed and power, and walking speed in elderly participants[81]. Using an isokinetic dynamometer to assess lower extremity power is a safe and convenient method for assessing power output from the lower limb in older adults[81]. Moreover, it has shown to be safe and acceptable for all age groups and levels of physical capability[98-100].

Muscle biopsies

All muscle biopsies were performed after an overnight fast. Muscle biopsies were biopsies were obtained from the vastus lateralis using the percutaneous needle biopsy biopsy technique [101]. The vastus lateralis is a good representative muscle for the *in vitro vitro* study of skeletal muscle in older persons [88]. Using sterile technique, 1% lidocaine (3-5 ml) was injected, first intracutaneously, then percutaneously, to anesthetize the skin, subcutaneous tissues, and down to, but not through, the fascia lata. A 6-7mm incision was made with a number 11 blade parallel to the skin lines and a 6mm University College Hospital needle is inserted. The needle was positioned to pierce the skin at an angle of 45^{o} to the surface and was inserted to penetrate the muscle to a sufficient depth encompassing the entire cutting window. Muscle tissue was obtained with suction from a 60cc syringe or wall suction. Following the procedure, direct pressure was applied to the area for 10 minutes, followed by placement of an adhesive strip to close the wound, and then bandaged. Once the specimen was obtained, visible blood and connective tissue was removed, and portions for specific assays were partitioned.

The portion for histochemical analysis (≥20 mg) was oriented such that the fibers run longitudinally, mounted in a histology tray in embedding medium (optimal cutting temperature compound, Miles Laboratory), and were then frozen in isopentane and cooled to its freezing point with liquid nitrogen. Another portion was used for Ribonucleic acid (RNA) extraction (≥30 mg) and protein expression was snap frozen in liquid nitrogen (within 30 secs of the biopsy) and stored at -80°C until analyses. The sample that was used for physiological recordings (≥15 mg) was divided into longitudinal sections, placed in cold skinning solution [in mM: 125 potassium propionate, 20.0

imidazole (pH 7.0), 2.0 ethylene glycol tetraacetic acid (EGTA), 4.0 Adenosine-5'-triphosphate (ATP), 1.0 magnesium chloride, and 50% (vol/vol) glycerol], then stored at -20°C for a maximum of 30 days before single-fiber analysis. The composition of the skinning solution and the relaxing, submaximal, and maximal activating solutions are described in detail elsewhere[102].

Fiber Type Identification

Myosin heavy chain content was determined by sodium dodecyl polyacrylamide gel electrophoresis (SDS-PAGE), as described[103], with some modifications. Single muscle fiber segments were dissolved in sample buffer in polypropylene centrifuge tubes (15 ml) after the contraction experiments. The sample tubes were incubated for 5 min at 95°C and then ultrasonicated for 15 min. All muscle fibers were stored at −80°C and run on the electrophoresis system within 2 weeks. The acrylamide concentration was 4% (weight·volume^{-1}) in the stacking gel and 6% running gel, and the gel matrix included 30% glycerol. To detect MHC in gels, the Silver Stain Plus Kit (Bio-Rad, Hercules, CA) was used.

Lower Body Physical Performance

400-Meter Walk

The 400-meter walk is a measure used to assess functional ability in older adult populations. Performance on this test is a strong indicator of disability, morbidity and mortality in self-reported well-functioning older adults[104]. As such, the 400-meter walk is an important outcome measure in clinical intervention trials[105].

The test was conducted in the Sticht Center on Aging at Wake Forest Baptist Medical Center. Participants were asked to walk a 20m course for ten laps (40m per lap). They were verbally instructed to walk as quickly as possible, without running, at a speed they could maintain for ten laps. Participants using a walking device were asked to attempt the test without their device. If this made them feel unsafe, they were allowed to use their walking device. Those who still felt unsafe with their device did not attempt the test. Participants were instructed to stop walking if they developed chest pain, significant shortness of breath or they were too uncomfortable to continue. If they showed signs of these symptoms, examiners suggested participants take a brief rest. In these instances, examiners asked participants to stand stationary, after thirty seconds they were asked to continue. If they could not continue after sixty seconds rest, the test was stopped. If the test was terminated prior to a participant completing 400 meters, there accomplished distance was recorded. The total number of rest stops and the duration of each were recorded using the rubric in Table 6.

Table 6. 400 Meter Walk Rest Stop Log

	< 30 s	31-60 s	> 60 s (test stopped)
Rest Stop #1:			
Rest Stop #2:			
Rest Stop #3:			
Rest Stop #4:			
Rest Stop #5:			
Rest Stop #6:			
Rest Stop #7:			
Rest Stop #8:			
Rest Stop #9:			
Rest Stop #10:			
Total #:			

Prior to the test, the examiner demonstrated one lap and addressed any concerns. During the test, standard verbal encouragement and lap number were provided. Throughout the test, the examiner followed behind and to the side of each participant. Examiners were instructed be at a distance close enough to provide support, but far enough so as not to alter the participants pace. The examiner recorded the time in minutes needed for each participant to complete the course.

Short Physical Performance Battery

The SPPB is a measure of lower-extremity physical function consisting of gait speed, balance, and repeated chair stands. It is a well-studied composite measure and a strong predictor of disability, institutionalization, morbidity and mortality in initially non-disabled older persons[106-110]. The reliability of the SPPB and its individual components are good with intra-class correlation coefficients above 0.88. The SPPB is also sensitive to change[111,112]. Even small changes of 0.5-0.6 points have been shown to be clinically meaningful [113,114] It has recently been advocated as an important primary outcome to be used in RCTs designed to develop evidenced-based interventions to prevent or postpone functional decline[115].

Usual Gait Speed

Gait speed was assessed by asking the participants to walk at their usual pace over a 4-meter course. They were instructed to stand with both feet touching the starting line and to start walking after a specific verbal command. Timing began when the command was given, and the time needed to complete the distance was recorded. Participants completed the task twice and only the faster time was analyzed.

The score for gait speed was calculated by dividing the distance (4 m) by the time to complete the course. Scores ranged from 0-4 based on speed ($m \cdot s^{-1}$), 4 being the best. Participants that were unable to complete the task were assigned a score of 0. A score of 1 was assigned if they finished, but took longer than 3.00 s (<.41 $m \cdot s^{-1}$); a score of 2 was assigned if the course was completed between 2.32-3.00 s (.041-.57 $m \cdot s^{-1}$); a score of 3 was assigned if the course was completed between 1.64-2.28 s (.58-.75 $m \cdot s^{-1}$); and a score of 4 was assigned if the was completed in less than 1.64 s (>.75 $m \cdot s^{-1}$) (Table 7).

Table 7. Categories of Performance: Test of Usual Gait Speed

Score	Speed (m/s)
0	Unable to Complete
1	<0.41
2	0.41-0.57
3	0.58-.75
4	>0.75

Repeated Chair Stands

The repeated chair stand test was performed using a straight-backed chair, which was placed with its back against a wall. Participants were first asked to stand from a sitting position without using their arms. If they were able to perform the task, they were then asked to stand up and sit down 5 times as quickly as possible and time to complete the task was recorded.

The score for chair stands was based on time to complete the chair stands and ranged for 0-4; with for being the fastest. Participants who were unable to complete the task were assigned a score of 0. A score of 1 was assigned if they were able to complete the task but took longer than 16.7 s; a score of 2 was assigned for completing the task between 13.7-16.7 s; a score of 3 was assigned for completing the task between 11.2-13.7

s; and a score of 4 was assigned for completing the task in less than 11.2 s (Table 8).

Table 8. Categories of Performance: Chair Stands

Score	Time (s)
0	Unable to Complete
1	>16.7
2	13.7-16.7
3	11.2-13.7
4	<11.2

Standing Balance

Participants were asked to maintain balance in three positions, characterized by a progressive narrowing of the base of support: feet together (side by side), the heel of one foot beside the big toe of the other foot (semi-tandem), and the heel of one foot in front of and touching the toes of the other foot (tandem). For each of the three positions, participants were timed to a maximum of 10 s.

The score for standing balance was based on the performance of the three positions. The scores ranged from 0-4, with four being the best. For the test of standing balance, participants were assigned a score of zero if they were unable to stand unassisted. They were assigned a one if they could hold a side-by-side standing position for 10 s; but were unable to hold a semi-tandem position for 10 s. A score of two was assigned if they could hold a semi-tandem for 10 s, but were unable to hold a full-tandem position for more than 2 s. A score of three was assigned if they could stand in a full-tandem position for 3-9s. A score of four was assigned for standing in a full-tandem position for 10 s (Table 9).

Table 9. Categories of Performance: Test of Standing Balance

Score	Side-by Side Stand (s)	Semi-tandem Stand (s)	Full Tandem Stand (s)
0	0-9, Unable or NA	< 10, Unable or NA	
1	10	0-9, Unable or NA	
2		10	0-2, Unable or NA
3		10	3-9
4		10	10

Lower Body Function Score

The sum of scores from usual gait speed, repeated chair stands, and standing balance was used to determine the level of lower extremity function. Therefore, the SPPB score range was from 0-12[108].

Data Analysis

Statistical analyses were performed using SPSS, Version 21 and Excel 2013. Statistical significance for the study was set at $p < 0.05$ level.

Descriptive Statistics

Descriptive statistics of baseline data included means, standard deviations and ranges of; age, height, body mass, FM, MM muscle strength, muscle power, MHC% of muscle fiber type, SPPB scores and 400-meter walk time. Males and females were analyzed separately. Independent t-tests were conducted to determine significant differences.

Dominance Analysis

A dominance analysis was used to calculate general dominance of muscle functions components and muscle fiber type on physical function. The variance of each individual muscle function component is examined while isolating the remaining components[116]. This will allow a comparison between muscle strength verses muscle power as factors in determining physical function. Moreover, the dominance analysis

investigates the dynamics of all possible individual subsets of muscle function's components as they related to physical function.

Multiple Linear Regression

A linear regression was generated predicting each measure of physical function from body composition, muscle function and fiber type was generated. The predictors were entered based on their dominance weights from highest to lowest.

RESULTS

Demographics

A total of 56 older adults were included in the analyses, 24 males and 29 females. Among the males, 24 were white and 2 were black. Among the females, 24 were white, 4 were black and 1 was Hispanic. Descriptive statistics are presented in Table 10.

Table 10. Descriptive Statistics

Variable	Males (n=26)		Females (n=29)	
	$\bar{x}$ ±SD	Range	$\bar{x}$ ±SD	Range
Age (yrs)	68.9 (3.8)	14	68.3 (3.2)	13
Height (m)*	1.76 (.058)	.27	1.60 (.053)	.20
Body Mass (kg)*	94.5 (9.9)	39.8	77.3 (9.4)	38.1
BMI (kg/m^2)	30.4 (2.3)	7.2	29.9 (2.2)	8.0

*Significant p = .05

Body Composition

Participants body composition measurements are shown in Table 11. One male did not have body composition data. Note that assessments of total body, left leg and right leg MM and FM were by DXA while assessments of the fat, muscle, and total thigh volume were by CT. On average, males tended to have more MM and muscle volume (MV) and less FM and Fat Volume (FV), compared to females. However, there were no significant differences ($p > .05$) in body composition between sexes. Within sex, there were no significant differences ($p > .05$) between left and right leg FM or MM.

Table 11. Body Composition

Variable	Males		Females	
	$\bar{x}$ ±SD	Range	$\bar{x}$ ±SD	Range
MM (kg)	63.4 (6.2)	31.6	43.1 (4.7)	19.4
FM (kg)	31.1 (5.4)	21.1	34.5 (5.7)	22.7
Left Leg				
FM (kg)	4.5 (.99)	4.1	6.0 (1.1)	4.5
MM (kg)	10.2 (11.6)	5.6	6.7 (.89)	3.5
Right Leg				
FM (kg)	4.6 (.97)	3.9	6.1 (1.2)	4.8
MM (kg)	10.5 (11.1)	4.9	6.9 (.89)	3.5
Thigh Vol (cm^3)	1465.5 (167.5)	577.4	1501.4 (207.6)	787.2
Fat Vol (cm^3)	579.0 (152.7)	655.3	883.9 (191.2)	699.3
Muscle Vol (cm^3)	792.4 (77.9)	290.4	530 (56.3)	232.9

FM = Fat Mass
MM = Muscle Mass
Vol = Volume

Muscle Fiber Type

Data for the percentages of Type I and Type II MHC% are presented in Table 12. Muscle biopsy samples were mostly from the left leg (right leg biopsies n = 5). Since the MHC% of muscle fiber type is a ratio, only the MHC% of type II muscle fibers were included in the dominance analysis.

Table 12. Muscle Fiber Type

Fiber Type	Males	Females
	$\bar{x}$	$\bar{x}$
Type I MHC (%)	42.3 (12.1)	49.9 (15.2)
Type II MHC (%)	57.7 (12.1)	50.1 (15.2)

Muscle Function

Data from the second trial on BV1 from the left leg was used to define muscle strength, muscle power, and muscle quality (Table 12). Testing for the left leg was not conducted on two male participants due to contraindications. For these two cases, data from their right leg was used for analyses. On average,

males had significantly greater ($p < .05$) muscle strength and muscle power, measured at both $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$, for both legs. There was no significant difference in muscle quality of right (p=.74) or left (p=.41) leg between sexes. Within sex, there were no significant difference ($p > .05$) in muscle strength, muscle power or muscle quality between the right and left leg.

Table 13. Muscle Function

Variable	Velocity $°\cdot s^{-1}$	Leg	Males		Females	
			$\bar{x}$ ±SD	Range	$\bar{x}$ ±SD	Range
Strength (Nm)	60	L	138.5 (40.6)	156.4	102.1 (30.4)	138.1
	240	L	74.8 (26.9)	98.2	52.9 (22.3)	101.8
	60	R	138.6 (42.8)	151.4	105.8 (30.4)	119.7
	240	R	79.7 (27.7)	126.4	55.3 (19.3)	90.9
Power (W)	60	L	8436.7 (2458.4)	9478.7	6231.4 (1852.8)	8428.3
	240	L	16830.1 (6470.2)	26397.6	12033.5 (5712.9)	27674.9
	60	R	8409.7 (2608.9)	9174.7	6447.9 (1864.9)	7384.5
	240	R	18043.7 (6186.6)	30532.3	12202.5 (5339.6)	24657.4
Quality ($Nm\cdot kg^{-1}$)		L	14.6 (2.7)	9.3	13.7 (2.5)	9.7
		R	14.2 (2.8)	13.2	13.5 (2.4)	8.5

Lower Body Physical Performance

Participant SPPB scores, gait speed and chair rise time are shown in Table 11. All participants completed each component of the SPPB. A score of 4 was achieved by all participants for the test of gait speed. For the test of standing balance, twenty-four females and twenty-three males achieved a score of 4, two males and three females achieved a score of 3 and 1 female achieved a score of 2. For the test of rising from a chair, eleven females and ten males achieve a score of 4, seven females and ten males achieved a score of 3, ten females and four males achieved a score of 2, and one male achieved a score of 1.

Participant's times for the 400-meter walk are shown in Table 11. One male did not complete the 400-meter walk and was not included in the dominance analysis. There was a significant difference ($p = 0.044$) in time to completed the 400-meter walk between sexes; males completed the walk more quickly than females.

Table 14. Assessments of Physical Function

SPPB Performance	Males		Females	
	$\bar{x}$ ±SD	Range	$\bar{x}$ ±SD	Range
Total	11.4 (.96)	3	10.9 (1.2)	5
Gait Speed (m/s)	3.56 (.39)	1.8	3.71 (.57)	2.0
Gait Score	4 (0)	0	4 (0)	0
Chair Stands (s)	11.8 (2.8)	10.5	10.7 (2.8)	10.6
Chair Score	3.1 (.86)	3	3.1 (.84)	2
Standing Balance	3.9 (.27)	1	3.8 (.62)	3
400m Walk Time (s)	287.7 (47.6)	190	302.2 (35.1)	139

Reliability of Isokinetic Testing

A reliability analysis comparing peak torques measured at $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$, from the second trial, during BV1 and BV2 is presented in Table 15. Intraclass correlation coefficients for muscle power and muscle strength, for both legs and for both sexes, were all >.900. Therefore, assessments from BV1 were used to define muscle power and muscle strength in our analyses.

Table 15. Reliability Analysis of Isokinetic Testing

Males				
Velocity °·s^{-1}	Leg	$\bar{x}$ (*SD*) (*95% C.I*)		ICC
		SV3	BV1	
60	R	126.6 (40.2) (110.3 to 142.8)	138.6 (42.6) (121.4 to 155.9)	.971
60	L	124.5 (34.7) (110.2 to 138.8)	138.5 (40.6) (121.8 to 155.3)	.959
240	R	70.3 (29.6) (58.4 to 82.3)	81.9 (22.0) (72.3 to 90.1)	.909
240	L	65.0 (22.7) (55.4 to 74.7)	75.8 (27.9) (64.2 to 87.3)	.943
Females				
Velocity	Leg	$\bar{x}$ (*SD*) (95% C.I)		ICC
		Series 1	Series 2	
60	R	108.8 (36.7) (94.9 to 122.8)	105.8 (30.4) (94.2 to 117.4)	.980
60	L	96.9 (32.6) (84.2 to 109.5)	102.1 (30.4) (90.3 to 113.9)	.975
240	R	54.4 (25.1) (44.9 to 63.9)	60.3 (21.0) (52.3 to 68.3)	.911
240	L	55.4 (22.7) (46.6 to 64.2)	53.4 (21.9) (44.9 to 61.9)	.972

(1) *Significant differences compared to SV2 measure (p<0.05)*
(2) *Significant differences compared to corresponding SV3 measure (p<0.05)*

Prediction of Physical Function

Dominance analyses comparing the unique variance contributions of FM, MM, muscle strength, muscle power, and muscle quality in all possible subsets with 400-meter walk time are displayed in Table 16 and Table 18. Linear regression models predicting 400-meter walk time are displayed in

Table 17 and Table 19Table 18. Dominance analyses were conducted for gait speed and chair rise time. Because < 10% of the variance was explained in both of these outcomes on average across all models, they are not included.

The most dominate factors for each sex was determined by comparing the general dominance of each variable. General dominance reflects the average additional unique variance contribution of each independent variable to all subset models. It represents the average difference in fit between all subset models[117]. Because the analysis partitions average total R^2 for each independent variable, they can be ranked based on their respective contribution to the regression effect across all possible subsets. Essentially the variable with the largest dominance weight is the most dominate because it explains more variance across all possible subsets of independent variables. Likewise, the variable with the smallest dominance weight is the least dominate because it explains less variance across all possible subsets of independent variables[116].

Dominance analysis results for predicting 400-meter walk time demonstrated that muscle power was the most dominate factor among males. The most dominate factor among females was muscle quality. The least dominate factor for both sexes was MHC% of type II muscle fibers, on average explaining

< .0010 of the variance across all possible models. The dominance analysis also demonstrated that FM was a suppressor variable in males, explaining more variance on variance on average (.0113), than by itself (.0061). Among females, FM and MM were suppressor variables, explaining more variance on average (FM - .0054) (MM - .0691), than by themselves (FM - .0004) (MM - 0152).

Linear regression models predicting 400-meter walk time are displayed in

Table 17 and Table 19. Variables were entered based on their dominance weight from highest to lowest. An analysis of variance (ANOVA) was used to determine the significance of each model.

Table 16. Dominance Weights for Males

K	FM[∓]	MM	Type II[†]	MS	MP*	MQ
0	0.0061	0.2181	0.0360	0.2025	0.3181	0.1555
X_1	0.0135	0.1507	0.0103	0.0984	0.2117	0.0811
X_2	0.0148	0.1133	0.0022	0.0420	0.1443	0.0407
X_3	0.0151	0.1024	0.0009	0.0298	0.1101	0.0344
X_4	0.0152	0.1140	0.0032	0.0569	0.1004	0.0596

X_5	0.0034	0.1357	0.0063	0.1088	0.0954	0.1032
$\bar{x}$	0.0113	0.1390	0.0098	0.0897	0.1634	0.0791

* *Most Dominate Predictor*
† *Least Dominate Predictor*
∓ *Suppressor*
K = # of subset variables
$\bar{x}$ = *General Dominance Weight*
MP = *Muscle Power*
MM = *Muscle Mass*
MS = *Muscle Strength*
MQ = *Muscle Quality*
FM = *Fat Mass*

Table 17. Regression Models for Males

Model		Coefficients		Std. Coefficients	t	Sig.	Model Sig.	R^2	Adj. R^2
		B	SE	Beta					
1		387.346	27.698		13.9	.000	0.002	0.386	.357
	MP	-.005	.001	-.621	-3.63	.002			
2		468.930	87.463		5.36	.000	0.005	0.414	.359
	MP	-.004	.002	-.519	-2.59	.017			
	MM	-1.523	1.549	-.197	-.983	.337			
3		458.848	89.420		5.13	.000	0.012	0.431	.342
	MP	-.006	.002	-.697	-2.24	.037			

	MM	-1.735	1.590	-.224	-1.09	.289			
	MS	.348	.460	.234	.755	.459			
4		533.739	116.16		4.59	.000	0.019	0.462	.342
	MP	-.005	.003	-.664	-2.12	.048			
	MM	-2.656	1.833	-.343	-1.44	.165			
	MS	1.031	0.818	.693	1.26	.224			
	MQ	-8.337	8.259	-.471	-1.00	.326			
5		542.071	121.97		4.44	.000	0.042	0.465	.308
	MP	-.005	.003	-.628	-1.85	.081			
	MM	-3.149	2.429	-.407	-1.29	.212			
	MS	1.093	0.861	.735	1.26	.222			
	MQ	-9.160	8.854	-.518	-1.03	.315			
	FM	.655	2.044	.074	.320	.753			
6		550.511	128.36		4.28	.001	0.87	0.498	.269
	MP	-.005	.003	-.614	-1.74	.100			
	MM	-3.241	2.515	-.419	-1.28	.216			
	MS	1.173	0.924	.789	1.27	.222			
	MQ	-9.967	9.475	-.563	-1.05	.308			
	FM	.861	2.206	.098	.390	.702			
	Type II	-.196	.641	-.064	-.306	.764			

MP = Muscle Power
MM = Muscle Mass
MS = Muscle Strength
MQ = Muscle Quality
FM = Fat Mass

Table 18. Dominance Weights for Females

K	FM$^{\overline{\top}}$	MM$^{\overline{\top}}$	Type II†	MS	MP	MQ*
0	0.0004	0.0152	0.0001	0.1388	0.0959	0.2061
X_1	0.0042	0.0174	0.0006	0.0899	0.0555	0.1683
X_2	0.0054	0.0369	0.0004	0.0632	0.0311	0.1564
X_3	0.0059	0.0703	0.0003	0.0563	0.0177	0.1674
X_4	0.0070	0.1133	0.0004	0.0659	0.0096	0.1974
X_5	0.0094	0.1614	0.0002	0.0881	0.0008	0.2419
$\bar{x}$	0.0054	0.0691	0.0003	0.0837	0.0351	0.1896

* *Most Dominate Predictor*
† *Least Dominate Predictor*
$\overline{\top}$ *Suppressor*

K = # of subset variables
$\bar{x}$ = *General Dominance Weight*
MP = *Muscle Power*
MM = *Muscle Mass*
MS = *Muscle Strength*
MQ = *Muscle Quality*
FM = *Fat Mass*

Table 19. Regression Coefficients for Females

Model		Coefficients		Std. Coefficients	t	Sig.	Model Sig.	R^2	Adj. R^2
		B	SE	Beta					
1		391.855	34.57		11.33	.000	0.015	0.207	.176
	MQ	-6.470	2.487	-.454	-2.60	.015			
2		394.315	36.87		10.69	.000	0.054	0.208	.145
	MQ	-5.796	3.917	-.407	-1.48	.151			
	MS	-0.130	0.574	-.062	-.226	.823			
3		667.367	115.4		5.77	.000	0.01	0.369	.290
	MQ	-21.139	7.161	-1.485	-2.95	.007			
	MS	2.319	1.120	1.112	2.07	.049			

	MM	-6.617	2.677	-.878	-2.47	.021			
4		672.105	118.1		5.68	.000	0.025	0.373	.264
	MQ	-21.366	7.313	-1.501	-2.92	.008			
	MS	2.114	1.254	1.013	1.68	.105			
	MM	-6.665	2.729	-.884	-2.44	.023			
	MP	0.002	0.004	.131	0.39	.697			
5		679.253	120.4		5.63	.000	0.046	0.383	.243
	MQ	-22.057	7.506	-1.549	-2.93	.008			
	MS	2.363	1.338	1.133	1.76	.091			
	MM	-7.593	3.170	-1.007	-2.39	.026			
	MP	0.001	0.005	.066	0.187	.854			
	FM	.845	1.407	.138	.600	.554			
6		677.984	124.2		5.457	.000	0.087	0.383	.207
	MQ	-22.055	7.682	-1.549	-2.87	.009			
	MS	2.361	1.369	1.132	1.72	.099			
	MM	-7.594	3.244	-1.007	-2.34	.029			
	MP	0.001	0.005	.067	0.185	.855			
	FM	.822	1.466	.134	.561	.581			
	Type II	.043	.521	.015	.082	.935			

MP = Muscle Power
MM = Muscle Mass
MS = Muscle Strength
MQ = Muscle Quality
FM = Fat Mass

DISCUSSION

The principal findings of this study were that, among the components of body composition, muscle function and muscle fiber type, muscle power was the most important predictor of lower body physical performance in older men. In older women, muscle quality was the most important predictor of lower body physical function performance. These findings are similar to those of previous studies in well-functioning older men[29,82] and women[27,31,87]. Our results indicate that the relationship between muscle function and lower body physical performance is modified by sex. To our knowledge, this is the first study to examine the specific contributions of each component of muscle function and muscle fiber type across all possible regression models in predicting lower body physical performance. These findings are important, as they may provide direction for interventions and exercise prescription aiming to improve physical function in older adults.

Predicting Lower Body Physical Function

We observed a difference between males and females in the most dominate predictor of lower body physical performance. In males, muscle power was the most important predictor in 400-meter walk time by itself (R^2 = .318) and on average across all models (R^2 = .164). Muscle strength explained 21% of the variance by itself and 9% on average across all models. This finding is similar to that found by Puthoff and Nelson in which muscle power explained more of the variance (48%) in Six-Minute Walk Time (SMWT), than muscle strength (38%)[29]. Muscle power has also been shown to explain more of the variance (2-

8%) in SPPB scores[29,82] and the time to walk 400 meters (5%)[118], compared to muscle strength[84].

It has been questioned whether these differences in explained variance are meaningful enough to suggest muscle power is a better determinate of physical function[119]. We calculated the general dominance weights, which partitions the total R^2. This identified the specific variance contribution of each component of muscle function in predicting time to walk 400 meters[116,117]. Notably, this method differs from that utilized in both product measures, which uses zero-order correlations and beta weights rather than unique variance. Moreover, product measures calculate relative weights based on the entire regression model and not across all possible subsets. We found the differences in explained variance of 400-meter walk time (X_0 = 11%, X_5 = 9%) between muscle strength and muscle power to be similar to the previously mentioned studies[29,82,119,120]. Puthoff, Janz and Nielsen[120] found greater differences between muscle power and muscle strength for the explained variance in average daily walking distance (21%). This result was found in an older population ($\bar{x}$ = 77.3 yrs), other than ours ($\bar{x}$ = 68.6 yrs). Muscle power is affected more by age than muscle strength[35], which may explain the discrepancy in these two studies.

In females, muscle quality was the most dominate factor in predicting lower body physical performance, explaining the largest amount of variance by itself (21%), and on average across all models (18%). Studies investigating lower body physical performance in older adults have found that the components of muscle function can impact men and women differently[27,121,122]. This discrepancy may be explained by differences in body composition between sexes. Women typically have a greater age-related increase in

FM[123] and accumulate additional FM during premenopausal period[124]. Also, women have higher fat accumulation within skeletal muscle. Moreover, the excess FM and fat accumulation impacts physical function in women to a greater extent than in men[27,121,122]. Women also have less muscle mass and muscle strength[125]. Although muscle power declines with age in both men and women, Yamauchi, Mishima & Nakayama[126] found no differences in velocity of lower limb multi-joint movements between young and older women. However, there was a significant difference between the two groups in maximal force production. This suggests that muscle strength may more important to physical function than muscle power in women. Consistent with this finding, our results indicated compared to muscle power, muscle strength explained more variance by itself (MS = 13%, MP = 9%) and across all possible regression models (MS = 8%, MP = 3%). It has demonstrated that the stretch-shorting cycle (SSC) is more beneficial to women, compared to similarly aged men[34]. This greater capacity to store and utilize elastic energy may attribute to differences in muscle function between sexes.

In our study there was not a significant difference in muscle quality between sexes, which is consistent with similar studies[31,87,127]. Despite this, the quality of muscle has been shown to impact physical function in women to a greater extent than in men[87]. Since women typically have more FM, less MM and less muscle strength compared to men, the quality of their muscle is more essential.

Muscle Fiber Type

In both sexes, we found that muscle fiber type was not an important factor in in predicting lower body physical performance, explaining a negligible amount of the variance (R^2 = .03 males, R^2 =.0001 females). The age related decline in MM is due to reduced fiber size, especially Type II fibers[57,64]. The selective loss of Type II fibers causes the rate of force development to decrease. Nevertheless, our results suggest that in both sexes, muscle function accounts for the variance explained by muscle fiber type in predicting 400-meter walk time. Contrary to this finding, Larsson, Grimby and Karlsson in an investigation on the relationship between changes in the vastus lateralis and functional performance using an isokinetic KE task, found that decreases in muscle fiber type were significantly correlated with decreases in muscle performance[64]. However, they did not assess multiple components of muscle function, which may explain the discrepancy between our findings and their data.

Practical Implications

Results from this study indicate that muscle power is the most important determinate among men in determining lower body physical performance. In females, muscle quality is the most important determinate of lower body physical performance. Exercise prescription for well-functioning overweight or obese older adults aimed and maintaining or improving lower body physical performance should be gender specific. That said, clinicians should not neglect any component of muscle function regardless of sex as each is related to lower body physical function.

Limitations

The findings from this study should be interpreted in the context of their limitations. First, the participants on average were high functioning (Mean SPPB: 11.4, females-10.9), mostly white and BMI between 27-35 kg/m^2. The nature of our sample limits the generalizability of our results. Future investigations should attempt to include minorities, lower functioning older adults with a boarder range of body composition. Second, the variance in 400-meter walk time explained in our study on average across all models was 49% for males and 38% for females. These results are significant, but they still leave a large part of the variance in lower body physical performance unexplained. Although, studies have demonstrated that older adults can improve physical function by improving muscle function,[119,128-131] other factors like aerobic capacity[132] and balance[133] also share a relationship with lower body physical function. Clinicians should consider other factors when examining and establishing an exercise program for elderly persons. Finally, the cross-sectional design of this study does not establish a causal relationship of muscle function to physical function. Studies comparing improvements in each component of muscle function, through exercise programs, and assessing physical function need to be conducted to support causal links.

Summary

As the number of older Americans increases, steps must be taken to diminish the consequences age-related decline in muscle function. Research on muscle function in the elderly has demonstrated its impact on physical function.

An understanding of this relationship is critical when prescribing exercise in this population. Findings from this study demonstrate that muscle function affects physical physical function differently between sexes. Muscle power may be the most important factor in men, and muscle quality may be the most important factor in women. Consideration should be given to differences in sex when prescribing exercise to overweight and obese older adults. Future studies should further examine the relationship between muscle function and physical function specific to males and females.

REFERENCES

1. Foundation KF. *Medicare spending and financing fact sheet.* 2011.
2. The state of US health, 1990-2010: burden of diseases, injuries, and risk factors. *JAMA.* 8/14/2013 2013;310(6):591-608.
3. Guralnik JM, Fried LP, Salive ME. Disability as a public health outcome in the aging population. *Annu.Rev.Public Health.* 1996 1996;17:25-46.:25-46.
4. Parekh AK, Goodman RA, Gordon C, Koh HK. Managing multiple chronic conditions: a strategic framework for improving health outcomes and quality of life. *Public Health Rep.* 7/2011 2011;126(4):460-471.
5. Morabia A, Ross A, Curtin F, Pichard C, Slosman DO. Relation of BMI to a dual-energy X-ray absorptiometry measure of fatness. *Br J Nutr.* Jul 1999;82(1):49-55.
6. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes.Res.* 9/1998 1998;6 Suppl 2:51S-209S.:51S-209S.
7. (CDC) CfDCaP. *Behavioral Risk Factor Surveillance System Survey Data.* Altanta, Georgia 2011 2011.
8. Vincent HK, Vincent KR, Lamb KM. Obesity and mobility disability in the older adult. *Obes.Rev.* 8/2010 2010;11(8):568-579.
9. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW, Jr. Body-mass index and mortality in a prospective cohort of U.S. adults. *N.Engl.J.Med.* 10/7/1999 1999;341(15):1097-1105.
10. Peeters A, Barendregt JJ, Willekens F, Mackenbach JP, Al MA, Bonneux L. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Ann.Intern.Med.* 1/7/2003 2003;138(1):24-32.
11. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *JAMA.* 1/8/2003 2003;289(2):187-193.
12. Stevens J, Cai J, Pamuk ER, Williamson DF, Thun MJ, Wood JL. The effect of age on the association between body-mass index and mortality. *N.Engl.J.Med.* 1/1/1998 1998;338(1):1-7.
13. Zamboni M, Mazzali G, Zoico E, et al. Health consequences of obesity in the elderly: a review of four unresolved questions. *Int.J.Obes.(Lond).* 9/2005 2005;29(9):1011-1029.
14. Strandberg TE, Stenholm S, Strandberg AY, Salomaa VV, Pitkala KH, Tilvis RS. The "Obesity Paradox," Frailty, Disability, and Mortality in Older Men: A Prospective, Longitudinal Cohort Study. *Am.J.Epidemiol.* 9/5/2013 2013.
15. Mokdad AH, Ford ES, Bowman BA, et al. Diabetes trends in the U.S.: 1990-1998. *Diabetes Care.* 9/2000 2000;23(9):1278-1283.
16. Somes GW, Kritchevsky SB, Shorr RI, Pahor M, Applegate WB. Body mass index, weight change, and death in older adults: the systolic hypertension in the elderly program. *Am.J.Epidemiol.* 7/15/2002 2002;156(2):132-138.
17. Despres JP. Dyslipidaemia and obesity. *Baillieres Clin.Endocrinol.Metab.* 7/1994 1994;8(3):629-660.
18. Felson DT, Anderson JJ, Naimark A, Walker AM, Meenan RF. Obesity and knee osteoarthritis. The Framingham Study. *Ann.Intern.Med.* 7/1/1988 1988;109(1):18-24.

19. Hart DJ, Spector TD. The relationship of obesity, fat distribution and osteoarthritis in women in the general population: the Chingford Study. *J.Rheumatol.* 2/1993 1993;20(2):331-335.
20. Santamaria F, Montella S, Greco L, et al. Obesity duration is associated to pulmonary function impairment in obese subjects. *Obesity.(Silver.Spring).* 8/2011 2011;19(8):1623-1628.
21. Wolk A, Gridley G, Svensson M, et al. A prospective study of obesity and cancer risk (Sweden). *Cancer Causes Control.* 1/2001 2001;12(1):13-21.
22. Villareal DT, Apovian CM, Kushner RF, Klein S. Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO, The Obesity Society. *Am.J.Clin.Nutr.* 11/2005 2005;82(5):923-934.
23. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA.* 4/5/2006 2006;295(13):1549-1555.
24. Guralnik JM, LaCroix AZ, Abbott RD, et al. Maintaining mobility in late life. I. Demographic characteristics and chronic conditions. *Am.J.Epidemiol.* 4/15/1993 1993;137(8):845-857.
25. Verbrugge LM, Jette AM. The disablement process. *Soc.Sci.Med.* 1/1994 1994;38(1):1-14.
26. Shumway-Cook A, Patla AE, Stewart A, Ferrucci L, Ciol MA, Guralnik JM. Environmental demands associated with community mobility in older adults with and without mobility disabilities. *Phys.Ther.* 7/2002 2002;82(7):670-681.
27. Jensen GL, Friedmann JM. Obesity is associated with functional decline in community-dwelling rural older persons. *J.Am.Geriatr.Soc.* 5/2002 2002;50(5):918-923.
28. Broadwin J, Goodman-Gruen D, Slymen D. Ability of fat and fat-free mass percentages to predict functional disability in older men and women. *J.Am.Geriatr.Soc.* 12/2001 2001;49(12):1641-1645.
29. Puthoff ML, Nielsen DH. Relationships among impairments in lower-extremity strength and power, functional limitations, and disability in older adults. *Phys.Ther.* 10/2007 2007;87(10):1334-1347.
30. Visser M, Langlois J, Guralnik JM, et al. High body fatness, but not low fat-free mass, predicts disability in older men and women: the Cardiovascular Health Study. *Am.J.Clin.Nutr.* 9/1998 1998;68(3):584-590.
31. Visser M, Goodpaster BH, Kritchevsky SB, et al. Muscle mass, muscle strength, and muscle fat infiltration as predictors of incident mobility limitations in well-functioning older persons. *J.Gerontol.A Biol.Sci.Med.Sci.* 3/2005 2005;60(3):324-333.
32. Wolinsky FD, Stump TE, Callahan CM, Johnson RJ. Consistency and change in functional status among older adults over time. *J.Aging Health.* 5/1996 1996;8(2):155-182.
33. Fried LP, Guralnik JM. Disability in older adults: evidence regarding significance, etiology, and risk. *J.Am.Geriatr.Soc.* 1/1997 1997;45(1):92-100.
34. Lindle RS, Metter EJ, Lynch NA, et al. Age and gender comparisons of muscle strength in 654 women and men aged 20-93 yr. *J.Appl.Physiol.* 11/1997 1997;83(5):1581-1587.

35. Metter EJ, Conwit R, Tobin J, Fozard JL. Age-associated loss of power and strength in the upper extremities in women and men. *J.Gerontol.A Biol.Sci.Med.Sci.* 9/1997 1997;52(5):B267-B276.
36. Doherty TJ. The influence of aging and sex on skeletal muscle mass and strength. *Curr.Opin.Clin.Nutr.Metab Care.* 11/2001 2001;4(6):503-508.
37. Goodpaster BH, Park SW, Harris TB, et al. The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study. *J.Gerontol.A Biol.Sci.Med.Sci.* 10/2006 2006;61(10):1059-1064.
38. Skelton DA, Greig CA, Davies JM, Young A. Strength, power and related functional ability of healthy people aged 65-89 years. *Age Ageing.* 9/1994 1994;23(5):371-377.
39. Lauretani F, Russo CR, Bandinelli S, et al. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. *J.Appl.Physiol.* 11/2003 2003;95(5):1851-1860.
40. Sartorio A, Proietti M, Marinone PG, Agosti F, Adorni F, Lafortuna CL. Influence of gender, age and BMI on lower limb muscular power output in a large population of obese men and women. *Int.J.Obes.Relat Metab Disord.* 1/2004 2004;28(1):91-98.
41. Lafortuna CL, Tresoldi D, Rizzo G. Influence of body adiposity on structural characteristics of skeletal muscle in men and women. *Clin.Physiol Funct.Imaging.* 6/24/2013 2013:10.
42. Janssen I, Heymsfield SB, Wang ZM, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. *J.Appl.Physiol.* 7/2000 2000;89(1):81-88.
43. Visser M, Kritchevsky SB, Goodpaster BH, et al. Leg muscle mass and composition in relation to lower extremity performance in men and women aged 70 to 79: the health, aging and body composition study. *J.Am.Geriatr.Soc.* 5/2002 2002;50(5):897-904.
44. Sternfeld B, Ngo L, Satariano WA, Tager IB. Associations of body composition with physical performance and self-reported functional limitation in elderly men and women. *Am.J.Epidemiol.* 7/15/2002 2002;156(2):110-121.
45. Baumgartner RN, Wayne SJ, Waters DL, Janssen I, Gallagher D, Morley JE. Sarcopenic obesity predicts instrumental activities of daily living disability in the elderly. *Obes.Res.* 12/2004 2004;12(12):1995-2004.
46. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *J.Am.Geriatr.Soc.* 5/2002 2002;50(5):889-896.
47. Reed RL, Pearlmutter L, Yochum K, Meredith KE, Mooradian AD. The relationship between muscle mass and muscle strength in the elderly. *J.Am.Geriatr.Soc.* 6/1991 1991;39(6):555-561.
48. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing.* Jul 2010;39(4):412-423.
49. Roubenoff R. Sarcopenia: effects on body composition and function. *J.Gerontol.A Biol.Sci.Med.Sci.* 11/2003 2003;58(11):1012-1017.

50. Lanza IR, Towse TF, Caldwell GE, Wigmore DM, Kent-Braun JA. Effects of age on human muscle torque, velocity, and power in two muscle groups. *J.Appl.Physiol (1985.).* 12/2003 2003;95(6):2361-2369.
51. Enoka RM. Muscle strength and its development. New perspectives. *Sports Med.* 9/1988 1988;6(3):146-168.
52. Frontera WR, Hughes VA, Lutz KJ, Evans WJ. A cross-sectional study of muscle strength and mass in 45- to 78-yr-old men and women. *J.Appl.Physiol.* 8/1991 1991;71(2):644-650.
53. Viitasalo J, Era P, Leskinen A, Heikkinen E. *Muscular strength profiles and anthropometry in random samples of men aged 31-35, 51-55 and 71-75 years.* 1985 1985. 28.
54. Hakkinen K, Hakkinen A. Muscle cross-sectional area, force production and relaxation characteristics in women at different ages. *Eur.J.Appl.Physiol Occup.Physiol.* 1991 1991;62(6):410-414.
55. Narici MV, Hoppeler H, Kayser B, et al. Human quadriceps cross-sectional area, torque and neural activation during 6 months strength training. *Acta Physiol Scand.* 6/1996 1996;157(2):175-186.
56. Porter MM, Vandervoort AA, Lexell J. Aging of human muscle: structure, function and adaptability. *Scand.J.Med.Sci.Sports.* 6/1995 1995;5(3):129-142.
57. Lexell J. Human aging, muscle mass, and fiber type composition. *J.Gerontol.A Biol.Sci.Med.Sci.* 11/1995 1995;50 Spec No:11-6.:11-16.
58. Nicol AC. Basic biomechanics of the musculoskeletal system: M. Nordin and V.H. Frankel, Lippincott, Philadelphia, PA, Williams and Wilkins, Baltimore, MD, ISBN 0-683-30247-7. *Journal of biomechanics.* 2002;35(6):872.
59. Billeter R, Weber H, Lutz H, Howald H, Eppenberger H, Jenny E. Myosin types in human skeletal muscle fibers. *Histochemistry.* 1980;65(3):249-259.
60. Zierath JR, Hawley JA. Skeletal muscle fiber type: influence on contractile and metabolic properties. *PLoS biology.* 2004;2(10):e348.
61. Trappe S, Creer A, Minchev K, et al. Human soleus single muscle fiber function with exercise or nutrition countermeasures during 60 days of bed rest. *Am.J.Physiol Regul.Integr.Comp Physiol.* 3/2008 2008;294(3):R939-R947.
62. Essen-Gustavsson B, Borges O. Histochemical and metabolic characteristics of human skeletal muscle in relation to age. *Acta Physiol Scand.* 1/1986 1986;126(1):107-114.
63. Jakobsson F, Borg K, Edstrom L. Fibre-type composition, structure and cytoskeletal protein location of fibres in anterior tibial muscle. Comparison between young adults and physically active aged humans. *Acta Neuropathol.* 1990 1990;80(5):459-468.
64. Larsson L, Sjodin B, Karlsson J. Histochemical and biochemical changes in human skeletal muscle with age in sedentary males, age 22--65 years. *Acta Physiol Scand.* 5/1978 1978;103(1):31-39.
65. Lexell J, Downham D. What determines the muscle cross-sectional area? *J.Neurol.Sci.* 8/1992 1992;111(1):113-114.
66. Scelsi R, Marchetti C, Poggi P. Histochemical and ultrastructural aspects of m. vastus lateralis in sedentary old people (age 65--89 years). *Acta Neuropathol.* 1980 1980;51(2):99-105.

67. Tomlinson BE, Irving D. The numbers of limb motor neurons in the human lumbosacral cord throughout life. *J.Neurol.Sci.* 11/1977 1977;34(2):213-219.
68. Deschenes MR. Effects of aging on muscle fibre type and size. *Sports Med.* 2004 2004;34(12):809-824.
69. Mirkov DM, Nedeljkovic A, Milanovic S, Jaric S. Muscle strength testing: evaluation of tests of explosive force production. *Eur.J.Appl.Physiol.* 3/2004 2004;91(2-3):147-154.
70. Abernethy P, Wilson G, Logan P. Strength and power assessment. Issues, controversies and challenges. *Sports Med.* 6/1995 1995;19(6):401-417.
71. Hunter S, White M, Thompson M. Techniques to evaluate elderly human muscle function: a physiological basis. *J.Gerontol.A Biol.Sci.Med.Sci.* 5/1998 1998;53(3):B204-B216.
72. Jaric S. Muscle strength testing: use of normalisation for body size. *Sports Med.* 2002 2002;32(10):615-631.
73. Hislop HJ, Perrine JJ. The isokinetic concept of exercise. *Phys.Ther.* 2/1967 1967;47(2):114-117.
74. Thistle HG, Hislop HJ, Moffroid M, Lowman EW. Isokinetic contraction: a new concept of resistive exercise. *Arch.Phys.Med.Rehabil.* 6/1967 1967;48(6):279-282.
75. Watkins MP, Harris BA. Evaluation of isokinetic muscle performance. *Clin.Sports Med.* 3/1983 1983;2(1):37-53.
76. Macaluso A, De VG. Muscle strength, power and adaptations to resistance training in older people. *Eur.J.Appl.Physiol.* 4/2004 2004;91(4):450-472.
77. Carpenter MR, Carpenter RL, Peel J, et al. The reliability of isokinetic and isometric leg strength measures among individuals with symptoms of mild osteoarthritis. *J.Sports Med.Phys.Fitness.* 12/2006 2006;46(4):585-589.
78. Sole G, Hamren J, Milosavljevic S, Nicholson H, Sullivan SJ. Test-retest reliability of isokinetic knee extension and flexion. *Arch.Phys.Med.Rehabil.* 5/2007 2007;88(5):626-631.
79. Brill PA, Macera CA, Davis DR, Blair SN, Gordon N. Muscular strength and physical function. *Med.Sci.Sports Exerc.* 2/2000 2000;32(2):412-416.
80. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. *J.Clin.Epidemiol.* 2/1993 1993;46(2):153-162.
81. Bassey EJ, Fiatarone MA, O'Neill EF, Kelly M, Evans WJ, Lipsitz LA. Leg extensor power and functional performance in very old men and women. *Clin.Sci.(Lond).* 3/1992 1992;82(3):321-327.
82. Reid KF, Fielding RA. Skeletal muscle power: a critical determinant of physical functioning in older adults. *Exerc.Sport Sci.Rev.* 1/2012 2012;40(1):4-12.
83. Foldvari M, Clark M, Laviolette LC, et al. Association of muscle power with functional status in community-dwelling elderly women. *J.Gerontol.A Biol.Sci.Med.Sci.* 4/2000 2000;55(4):M192-M199.
84. Bean JF, Leveille SG, Kiely DK, Bandinelli S, Guralnik JM, Ferrucci L. A comparison of leg power and leg strength within the InCHIANTI study: which influences mobility more? *J.Gerontol.A Biol.Sci.Med.Sci.* 8/2003 2003;58(8):728-733.

85. Bassey EJ, Short AH. A new method for measuring power output in a single leg extension: feasibility, reliability and validity. *Eur.J.Appl.Physiol Occup.Physiol.* 1990 1990;60(5):385-390.
86. Schroeder ET, Wang Y, Castaneda-Sceppa C, et al. Reliability of maximal voluntary muscle strength and power testing in older men. *J.Gerontol.A Biol.Sci.Med.Sci.* 5/2007 2007;62(5):543-549.
87. Newman AB, Haggerty CL, Goodpaster B, et al. Strength and muscle quality in a well-functioning cohort of older adults: the Health, Aging and Body Composition Study. *J.Am.Geriatr.Soc.* 3/2003 2003;51(3):323-330.
88. Trappe TA, Lindquist DM, Carrithers JA. Muscle-specific atrophy of the quadriceps femoris with aging. *J.Appl.Physiol.* 6/2001 2001;90(6):2070-2074.
89. Koster A, Ding J, Stenholm S, et al. Does the amount of fat mass predict age-related loss of lean mass, muscle strength, and muscle quality in older adults? *J.Gerontol.A Biol.Sci.Med.Sci.* 8/2011 2011;66(8):888-895.
90. St-Onge MP. Relationship between body composition changes and changes in physical function and metabolic risk factors in aging. *Curr.Opin.Clin.Nutr.Metab Care.* 9/2005 2005;8(5):523-528.
91. Avila JJ, Gutierres JA, Sheehy ME, Lofgren IE, Delmonico MJ. Effect of moderate intensity resistance training during weight loss on body composition and physical performance in overweight older adults. *Eur J Appl Physiol.* Jun 2010;109(3):517-525.
92. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J.Psychiatr.Res.* 11/1975 1975;12(3):189-198.
93. McCarthy CJ, Callaghan MJ, Oldham JA. The reliability of isometric strength and fatigue measures in patients with knee osteoarthritis. *Man.Ther.* 5/2008 2008;13(2):159-164.
94. Metter EJ, Talbot LA, Schrager M, Conwit RA. Arm-cranking muscle power and arm isometric muscle strength are independent predictors of all-cause mortality in men. *J.Appl.Physiol.* 2/2004 2004;96(2):814-821.
95. Laukkanen P, Heikkinen E, Kauppinen M. Muscle strength and mobility as predictors of survival in 75-84-year-old people. *Age Ageing.* 11/1995 1995;24(6):468-473.
96. Rantanen T, Harris T, Leveille SG, et al. Muscle strength and body mass index as long-term predictors of mortality in initially healthy men. *J.Gerontol.A Biol.Sci.Med.Sci.* 3/2000 2000;55(3):M168-M173.
97. Delmonico MJ, Harris TB, Lee JS, et al. Alternative definitions of sarcopenia, lower extremity performance, and functional impairment with aging in older men and women. *J.Am.Geriatr.Soc.* 5/2007 2007;55(5):769-774.
98. Pearson SJ, Cobbold M, Orrell RW, Harridge SD. Power output and muscle myosin heavy chain composition in young and elderly men. *Med.Sci.Sports Exerc.* 9/2006 2006;38(9):1601-1607.
99. McDermott MM, Tian L, Ferrucci L, et al. Associations between lower extremity ischemia, upper and lower extremity strength, and functional impairment with peripheral arterial disease. *J.Am.Geriatr.Soc.* 4/2008 2008;56(4):724-729.

100. Cousins JM, Petit MA, Paudel ML, et al. Muscle power and physical activity are associated with bone strength in older men: The osteoporotic fractures in men study. *Bone.* 8/2010 2010;47(2):205-211.
101. O'Rourke KS, Ike RW. Muscle biopsy. *Curr.Opin.Rheumatol.* 11/1995 1995;7(6):462-468.
102. Godard MP, Gallagher PM, Raue U, Trappe SW. Alterations in single muscle fiber calcium sensitivity with resistance training in older women. *Pflugers Arch.* 6/2002 2002;444(3):419-425.
103. Giulian GG, Moss RL, Greaser M. Improved methodology for analysis and quantitation of proteins on one-dimensional silver-stained slab gels. *Anal.Biochem.* 3/1983 1983;129(2):277-287.
104. Newman AB, Simonsick EM, Naydeck BL, et al. Association of long-distance corridor walk performance with mortality, cardiovascular disease, mobility limitation, and disability. *JAMA.* 5/3/2006 2006;295(17):2018-2026.
105. Rejeski WJ, Axtell R, Fielding R, et al. Promoting physical activity for elders with compromised function: the lifestyle Interventions and Independence for elders (LIFE) study physical activity intervention. *Clinical interventions in aging.* 2013;8:1119-1131.
106. Penninx BW, Ferrucci L, Leveille SG, Rantanen T, Pahor M, Guralnik JM. Lower extremity performance in nondisabled older persons as a predictor of subsequent hospitalization. *J.Gerontol.A Biol.Sci.Med.Sci.* 11/2000 2000;55(11):M691-M697.
107. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N.Engl.J.Med.* 3/2/1995 1995;332(9):556-561.
108. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J.Gerontol.* 3/1994 1994;49(2):M85-M94.
109. Guralnik JM, Ferrucci L, Pieper CF, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J.Gerontol.A Biol.Sci.Med.Sci.* 4/2000 2000;55(4):M221-M231.
110. Onder G, Penninx BW, Ferrucci L, Fried LP, Guralnik JM, Pahor M. Measures of physical performance and risk for progressive and catastrophic disability: results from the Women's Health and Aging Study. *J.Gerontol.A Biol.Sci.Med.Sci.* 1/2005 2005;60(1):74-79.
111. Pahor M, Blair SN, Espeland M, et al. Effects of a physical activity intervention on measures of physical performance: Results of the lifestyle interventions and independence for Elders Pilot (LIFE-P) study. *J.Gerontol.A Biol.Sci.Med.Sci.* 11/2006 2006;61(11):1157-1165.
112. Ostir GV, Volpato S, Fried LP, Chaves P, Guralnik JM. Reliability and sensitivity to change assessed for a summary measure of lower body function: results from the Women's Health and Aging Study. *J.Clin.Epidemiol.* 9/2002 2002;55(9):916-921.

113. Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful change and responsiveness in common physical performance measures in older adults. *J.Am.Geriatr.Soc.* 5/2006 2006;54(5):743-749.
114. Nieves JW, Li T, Zion M, et al. The clinically meaningful change in physical performance scores in an elderly cohort. *Aging Clin.Exp.Res.* 12/2007 2007;19(6):484-491.
115. Vasunilashorn S, Coppin AK, Patel KV, et al. Use of the Short Physical Performance Battery Score to predict loss of ability to walk 400 meters: analysis from the InCHIANTI study. *J.Gerontol.A Biol.Sci.Med.Sci.* 2/2009 2009;64(2):223-229.
116. Azen R, Budescu DV. The dominance analysis approach for comparing predictors in multiple regression. *Psychol.Methods.* 6/2003 2003;8(2):129-148.
117. Nathans LL, Oswald FL, Nimon K. Interpreting multiple linear regression: A guidebook of variable importance. *Practical Assessment, Research & Evaluation.* 2012;17(9):2.
118. Marsh AP, Miller ME, Saikin AM, et al. Lower extremity strength and power are associated with 400-meter walk time in older adults: The InCHIANTI study. *J Gerontol A Biol Sci Med Sci.* Nov 2006;61(11):1186-1193.
119. Marsh AP, Miller ME, Rejeski WJ, Hutton SL, Kritchevsky SB. Lower extremity muscle function after strength or power training in older adults. *J Aging Phys Act.* Oct 2009;17(4):416-443.
120. Puthoff ML, Janz KF, Nielson D. The relationship between lower extremity strength and power to everday walking behaviors in older adults with functional limitations. *J Geriatr Phys Ther.* 2008;31(1):24-31.
121. Friedmann JM, Elasy T, Jensen GL. The Relationship Between Body Mass Index and Self-Reported Functional Limitation Among Older Adults: A Gender Difference. *Journal of the American Geriatrics Society.* 2001;49(4):398-403.
122. Tseng LA, Delmonico MJ, Visser M, et al. Body composition explains sex differential in physical performance among older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences.* 2014;69(1):93-100.
123. Poehlman ET, Toth MJ, Bunyard LB, et al. PHysiological predictors of increasing total and central adiposity in aging men and women. *Archives of Internal Medicine.* 1995;155(22):2443-2448.
124. Poehlman ET, Toth MJ, Gardner AW. Article RETRACTED: Changes in Energy Balance and Body Composition at Menopause: A Controlled Longitudinal Study. *Annals of Internal Medicine.* 1995;123(9):673-675.
125. Hakkinen K, Kraemer WJ, Kallinen M, Linnamo V, Pastinen UM, Newton RU. Bilateral and unilateral neuromuscular function and muscle cross-sectional area in middle-aged and elderly men and women. *J Gerontol A Biol Sci Med Sci.* Jan 1996;51(1):B21-29.
126. Yamauchi J, Mishima C, Nakayama S, Ishii N. Force–velocity, force–power relationships of bilateral and unilateral leg multi-joint movements in young and elderly women. *Journal of biomechanics.* 2009;42(13):2151-2157.

127. Lynch N, Metter E, Lindle R, et al. Muscle quality. I. Age-associated differences between arm and leg muscle groups. *Journal of Applied Physiology.* 1999;86(1):188-194.
128. Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in community-dwelling older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences.* 2003;58(2):M171-M175.
129. Liu C-J, Latham NK. Progressive resistance strength training for improving physical function in older adults. *Cochrane Database Syst Rev.* 2009;3(3).
130. de Vos NJ, Singh NA, Ross DA, Stavrinos TM, Orr R, Singh MAF. Optimal load for increasing muscle power during explosive resistance training in older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences.* 2005;60(5):638-647.
131. Earles DR, Judge JO, Gunnarsson OT. Velocity training induces power-specific adaptations in highly functioning older adults. *Archives of physical medicine and rehabilitation.* 2001;82(7):872-878.
132. Fleg JL, Morrell CH, Bos AG, et al. Accelerated longitudinal decline of aerobic capacity in healthy older adults. *Circulation.* 2005;112(5):674-682.
133. King AC, Rejeski WJ, Buchner DM. Physical activity interventions targeting older adults. A critical review and recommendations. *Am J Prev Med.* Nov 1998;15(4):316-333.

APPENDIX

Appendix A

Section on Gerontology and Geriatric

Improving Muscle for Functional Independence Trial (I'M FIT)

Informed Consent Form to Participate in Research
Barbara Nicklas, PhD, Principal Investigator

Introduction
You are invited to be in a research study. Research studies are designed to gain scientific knowledge that may help other people in the future. You are being asked to take part in this study because you are between the ages of 65-79 years, are not participating in a strength training program on a regular basis, fit the height and weight requirement, and because you are interested in participating in an exercise study. Your participation is voluntary. Please take your time in making your decision as to whether or not you wish to participate. Please ask the study staff to explain any words or information contained in this informed consent document that you do not understand. You may also discuss the study with your friends and family.

Why Is This Study Being Done?
This study will determine whether adding a low calorie diet to strength training will improve muscle strength and overall physical function more than just strength training only.

How Many People Will Take Part in the Study?
A total of 130 men and women will participate in the study. In order to identify the 130 people needed, we may need to screen as many as 250 because some people will not qualify to be included in the study. This study will take place at the Geriatric Research Center (GRC) and the Geriatric Clinical Research Unit (G-CRU) in the J. Paul Sticht Center on Aging at Wake Forest University Health Sciences and the Clinical Research Center (CRC) at Wake Forest University.

What Is Involved in the Study?
If you agree to participate in this study by signing this consent form, you will be asked to complete three screening visits to see if you qualify for the study. You will then be asked to complete one testing visit before beginning the 5- month intervention and three other visits after the intervention. The details about all study visits and procedures are provided below. We will make every effort to follow the visit procedures in the order they are outlined below; however, it may be necessary at times to make changes to accommodate different schedules.

Screening Visit 1 (SV1)
We will ask that you come to the Geriatric Clinical Research Unit (G-CRU) having fasted for at least 8 hours prior to your appointment time, with nothing to eat or drink except water. At this visit, you will learn more details about the study and you will be given time to ask questions and get satisfactory answers. Then, you will be asked to sign this informed consent form if you qualify for the study. After signing the consent form, we will:

- Measure your height and weight to determine your eligibility
- Draw blood (about 2 tablespoons) from a vein in your arm to test your blood sugar, cholesterol and fat levels, other blood cell counts and chemistries
- Provide you with a light breakfast snack
- Ask you to answer questions about your background, medical history, medications, and memory
- Measure your blood pressure
- Perform an Electrocardiogram (ECG) of your heart
- Ask you to do series of physical performance tests including balance tests, chair rise (stand up from a seated position in a chair 5 times), a short-distance (4-meters or 13-feet) walking speed test, and a narrow walk test

This visit will take approximately 1 ½ to 2 hours.

Screening Visit 2 (SV2)
Approximately one week later you will come to the Geriatric Research Center (GRC) for a second screening visit to undergo the following:

- Perform a long-distance walking test on our indoor walking course
- A test of your leg strength and a test of your grip strength
- Questionnaires that will measure your ability to do daily tasks
- A series of DXA (dual energy x-ray absorptiometry) scans, which are a painless scans of your body that determine the amount of bone, fat, and muscle you have (more details provided in the Risks Section of this form)
- Measurements of your waist, hip, abdomen and thigh using a tape measure

This visit will take approximately 2 to 2 ½ hours.

Screening Visit 3 (SV3)
Approximately one week later you will come to the Geriatric Research Center (GRC) for a second screening visit to undergo the following:

- A test of your leg strength
- A series of CT scans to determine the location of your body fat (more details provided in the Risks Section of this form)
- A variety of assessments that measure your vascular function. The battery of tests will include the use of 4 different machines. All of the machines require you to lie quietly on a table. At different times during the tests, blood pressure cuffs will be fitted to your arms and legs and ECG electrodes will be placed on your chest, neck, sides and forearms. A sensor will also be placed on the inside of your wrist

to obtain information from your pulse.

This visit will take approximately 2½ to 3 hours.

Baseline Visit 1 (BV1)
For this visit, we will ask that you come to the G-CRU having fasted for at least 8 hours prior to your appointment time, with nothing to eat or drink except water. At this visit, we will:

- Draw blood (about 2 tablespoons) from a vein in your arm to test levels of inflammation and other risk factors in your blood
- Use an ultrasound to assist in removing a sample of your leg muscle (more details provided in the Risks Section of this form)
- Provide you with a light breakfast snack

This visit takes approximately 1 to 1 ½ hours.

Randomization
At the end of the SV3 you will be randomized into one of the 2 study groups listed below. Randomization means that you are put into a group by chance, such as flipping a coin. You will have an equal chance of being placed in either of the 2 groups. You must agree to be in either group and you may not pick or change the group that you are placed in. You will participate in 1 of these groups for 5 months (up to 20 weeks).
The groups are:

- Strength training Only
- Strength training with a Diet designed for weight loss

Study groups (interventions)
Both groups will take part in a **Strength training** program for 20 weeks. All exercise will be done at the Clinical Research Center (CRC) off Shorefair Drive in Winston-Salem. You will exercise (strength train) 3 days a week on Nautilus resistance machines. Two study personnel, who are trained in basic life support, will supervise all exercise sessions. Blood pressure and heart rate will be measured and recorded before each exercise session. Training sessions will start with a warm-up by walking or cycling for 5 minutes followed by a series of stretches. The session will end with a cool down of light stretching. You will be asked to wear comfortable clothing and good walking shoes.

If you are placed in the **Strength training Only** group, you will be instructed to maintain your regular dietary intake that matches your calculated energy needs during the course of the study.

If you are placed in the **Strength training + Diet** group you will be asked to eat a low calorie diet for 20 weeks. This diet contains approximately 600 calories less than you need to maintain your current weight. This allows for an approximate weight loss of about 8-10% of your current weight. You will have an initial meeting with study staff to discuss the diet and the meal replacement choices. During the course of the 20 weeks, you will be asked to record all food and drinks in a logbook diary. A maximum of two meals replacements per day (shakes and bars) will be provided for you. You will be

responsible for providing your own dinner and snacks in accordance with the guidelines provided.

In addition, both groups will be provided with a daily calcium (1200 mg) and vitamin D (800 IU/d) supplement.

During the course of the 20 weeks of the intervention, some participants will also be contacted for telephone interviews to obtain a detailed report of their previous day's dietary intake. Those interviews will be conducted by a CRU nutritionist at (three/six) random time points and will each take approximately 15-30 minutes time.

Follow-up Visit 1 (FV1)

For this visit, we will ask that you come to the GRC during the last week that you are exercising. At this visit, we will ask you to undergo the following procedures/activities:

- A test of your leg strength and a test of your grip strength
- Questionnaires that will measure your ability to do daily tasks

This visit takes approximately $1^{1/2}$ hour.

Follow-up Visit 2 (FV2) – This visit may be combined with FV1

For this visit, we will ask that you come to the GRC to undergo the following procedures/activities:

- A series of physical performance tests including balance tests, chair rise (stand up from a seated position in a chair 5 times), a short-distance (4-meters or 13-feet) walking speed test, and a narrow walk test
- Perform a long-distance walking test on our indoor walking course
- A series of DXA (dual energy x-ray absorptiometry) scans, which are a painless scans of your body that determine the amount of bone, fat, and muscle you have (more details provided in the Risks Section of this form)
- A series of CT scans to determine the location of your body fat (more details provided in the Risks Section of this form)
- Measurements of your waist, hip, abdomen and thigh using a tape measure
- A variety of assessments that measure your vascular function. The battery of tests will include the use of 4 different machines. All of the machines require you to lie quietly on a table. At different times during the tests, blood pressure cuffs will be fitted to your arms and legs and ECG electrodes will be placed on your chest, neck, sides and forearms. A sensor will also be placed on the inside of your wrist to obtain information from your pulse.

This visit takes approximately 2 to 2½ hours.

Follow-up Visit 3 (FV3) - This visit may be combined with FV1 or FV2 if you don't have to have a repeat leg muscle sample taken

For this visit, we will ask that you come to the G-CRU having fasted for at least 8 hours prior to your appointment time, with nothing to eat or drink except water. At this visit, we will:

- Draw blood (about 4 tablespoons) from a vein in your arm to test your blood

sugar, cholesterol and fat levels, other blood cell counts and chemistries, levels of inflammation and other risk factors in your blood
- Remove a sample of your leg muscle (more details provided in the Risks Section of this form).You may not have to have this done if we were unable to get enough muscle from you during this first procedure.
- Provide you with a light breakfast snack

This visit takes approximately 1 to 1½ hours.

Storage of Biological Tissue

If you agree to participate in this study, 4 of the tablespoons of blood will be stored to use for future research. This sample will be kept frozen and may be used in future research to learn more about other diseases. Your sample will be stored in the Geriatrics laboratory in the Nutrition Research building at Wake Forest Baptist Medical Center (WFBMC) under the supervision of Dr. Barbara Nicklas, and it will be used only by researchers approved by Dr. Nicklas. An Institutional Review Board (IRB) must also approve any future research study using your sample.

Your blood sample will be stored with a unique identifier and will not include any identifiable information about you, such as your name, address, telephone number, social security number, medical record number or any of the identifiers outlined in the HIPAA Privacy Rule regulations. The unique identifier will be a randomly assigned number and only the principal investigator will have access to the code that links the unique identifier to you. Your name, address, social security number, etc. will never be disclosed to future researchers and neither will the code that links your identifiers to the sample.

The research that may be done with your blood sample is not designed to help you specifically. There is no personal benefit to you from taking part in this aspect of this study. It might help people who have diseases at some point in the future, but it is not known if this will happen. The results of the research done with your blood sample will not be given to you or your doctor. These results will not be put in your medical records. The research using your blood sample will not affect your care. Your blood sample will be used only for research and will not be sold. The findings from this research may result in the future development of products that are of commercial value. There are no plans to share any of the profits with you which may occur as a result of this research.

How Long Will I Be in the Study?

You will be in the study for about 6 months. You will be in the exercise program of the study for 5 of these months. You can stop participating at any time. If you decide to stop participating in the study we encourage you to talk to the study investigators or staff first.

What Are the Risks of the Study?

Being in this study involves some risk to you. You should discuss the risk of being in this study with the study investigators or staff. Risks and side effects related to the exercise program, study diet, and study procedures include:

1. Diet intervention

Although there are no known serious risks associated with eating a meal replacement diet to lose weight, changes in usual bowel function (diarrhea and/or constipation) may occur when beginning the new diet due to differences between this diet and your usual diet. Under conditions of rapid weight loss (more than 5 pounds per week), there is a very small chance of developing gallbladder disease. Rapid weight loss will be monitored by weighing you weekly and adjusting your caloric intake if necessary.

2. Strength training intervention

There exists the possibility that certain physical changes may occur during your participation in strength training. These include: abnormal blood pressure, fainting, abnormal heart beats, chest pain and, in rare instances, heart attack, stroke, or death. Every effort is made to minimize these risks by reviewing information about your health and fitness before the intervention begins, and by closely observing you during all testing procedures. Emergency equipment and trained personnel are available to deal with unusual situations that may arise.

All strength training classes will be supervised by exercise technicians, who will instruct you in proper exercise techniques. There may be some discomfort in the beginning of the study from increasing your physical activity. The possibilities include, but are not limited to, muscle and joint stiffness/soreness. This stiffness/soreness generally declines in 1 or 2 days and is not considered to be serious. You might experience an exercise-related injury such as a strain, sprain, or other injury to your muscles or joints. You might experience minor ailments such as foot pain, anxiety, fatigue, decreased appetite, dizziness, or other minor health occurrences.

3. Physical performance tests

Your ability to perform certain physical activities will be measured before and after the intervention. There is a slight risk of falls while participating in the balance test. However, you will be positioned beside a step or wall that can be reached immediately if you feel that you are going to lose your balance. Additionally, the person conducting the test will stand next to you at all times. You may have slight hand discomfort during the grip test, but this usually stops once the test is over. There is a small possibility that you may stumble, fall or aggravate one of your joints/muscles during the walking test or knee strength test.

4. Body measurements

Several methods will be used to determine your amount of fat, muscle and bone and the location of body fat. A tape measure will be used to measure the size of your waist, hip, abdomen and thigh. A dual energy X-ray absorptiometry machine (DXA) will measure the amount of your muscle, bone and fat. This machine uses photons (energy) which scan across your body while you are lying quietly on a padded table. Computed tomography (CT) scans of the abdomen, heart, and thigh will be used to determine whether body fat is located deep in the tissues or close to the body surface. The CT scan of your thigh will also determine the area of your leg muscles. Both the DXA and CT scans are painless, but do involve exposure to doses of x-rays. Other than minimal exposure to radiation, there are no risks associated with the CT or DXA scans.

The radiation dose that you will receive as a result of participating in this study includes radiation from DXA and CT scans. The amount of radiation you will receive from all the CT scans is 1690 millirem, and the amount of radiation you will receive from all the DXA scans is 30 millirem. You will receive a total radiation dose of 1720 millirem by participating in this study. This is equal to 34% of the yearly limit for radiation exposure allowed for radiation workers (5000 millirem).

The risk of these procedures is small. Please be aware that this radiation exposure is necessary for this research study only and is not essential for your medical care. The Wake Forest University/Baptist Medical Center's Radiation Safety Committee, a group of experts on radiation matters, has reviewed the use of radiation in this research study and has approved this use as being necessary to obtain the research information desired. The potential long-term risk from these radiation doses is uncertain, but these doses have never been associated with any definite adverse effects. Thus, the risk to you, if any, is estimated to be slight.

The scans are being conducted only for the purpose of research. It is a different test than what is used in the clinical setting to detect or discover medical conditions. It is not a substitute for a clinical scan. Research personnel will analyze the scan only for the specified research findings. If we should happen to see an abnormal finding that may be harmful to your health, we will notify you and your personal physician if you ask us to. Unexpected findings on the limited research scan will occasionally allow early discovery of a medical condition for which you may need treatment. They may also cause undue worry or result in additional testing, sometimes costly, which may or may not benefit your health.

5. Muscle sampling

To reduce the chance of bleeding, you cannot take aspirin, certain other pain relievers (like ibuprofen, Motrin™, Advil™, Aleve™) or other medications that may affect bleeding, platelets, or bruising for 5 days before and for 3 days after the procedure. It is OK to use acetaminophen (Tylenol™ or Extra-strength Tylenol™). You will also be asked to avoid strenuous physical activity for 36 hours before and after the procedure. You will be asked to fast (nothing to eat or drink except water for 8 hours before your visit). The muscle sample will be studied to measure factors affecting muscle function, strength, endurance, and metabolism. The entire procedure takes less than 45 minutes to complete and a snack will be provided after the sampling. The muscle sampling will be performed before and after the 5-month exercise intervention.

The skin of one of your thighs will be thoroughly cleaned and a local anesthetic (numbing medicine similar to what a dentist uses) will be used to numb your skin first and then your thigh muscle. After the numbing medicine takes effect, a very small incision (1/4 inch long) will be made in the skin of your thigh and a needle inserted to remove a small piece of muscle (about the size of a small pea). Sometimes, the doctor doesn't get enough muscle tissue the first time and will ask if you will allow the needle to be inserted for another try. After the needle is removed, the doctor will apply pressure to your leg to prevent bleeding into the tissue and will close the incision with small pieces

of sterile tape.

The numbing medicine injected into your muscle will reduce the discomfort felt during the muscle sampling. Temporary numbness of the skin near the sampling site can rarely occur, and very rarely, this numbness can persist. In addition, bruising can occur. You may feel pain or soreness in the area of the sampling after the local anesthetic wears off. There is a slight risk of bleeding into the tissue and infection; however, pressure is applied to stop the bleeding and this procedure is done under sterile conditions to protect against infection. You will be given instructions on how to care for the incision and treat any pain or discomfort before you leave the clinic. A very small scar (1/4 inch) may persist. If you are allergic to the local anesthetic, you may experience dizziness, anxiousness, numbness of the lips and tightness of the throat. Medications to treat your reaction are kept close by if needed. If you are allergic or sensitive to the adhesive tape, you may experience skin irritation or a rash where the tape was applied. These reactions go away within a short time. A very small number of individuals feel lightheaded or dizzy during, or immediately following, the procedure. If this should occur we will stop the procedure and perform appropriate treatment, including providing you with a snack or drink. There is no additional risk in using the ultrasound during the muscle sampling.

6. Calcium and Vitamin D Supplement
You will be asked to take a calcium and vitamin D supplement twice daily. There is a slight chance that you may develop constipation from taking calcium on a regular basis. This can be resolved by talking to the study staff and learning ways to incorporate more fiber and water into your diet. Please discuss this with the study staff should this occur.

7. Blood Draw
Blood samples (8 tablespoons total) will be drawn from a vein in your arm after an overnight fast before and after the intervention. You may experience discomfort, bruising and/or bleeding where the needle is inserted. Occasionally, some people become dizzy, lightheaded or feel faint. Infection may occur on rare occasions.

8. Vascular Function
During these tests you will have up to four blood pressure cuffs on your arms and legs. As they inflate, the pressure might be uncomfortable but should only last a few seconds. Several ECG electrodes are placed on your body, which are sticky and may be uncomfortable removing. In rare cases, the skin may become irritated from the electrode adhesive. The technician will write on your wrist with a pen to mark where your pulse is the strongest, but this mark can be easily wiped off. The pulse sensor may leave a small circular indentation from where it is pressed down on your wrist. The pressure is minimal and the indentation will go away within an hour.

Women of childbearing age are excluded from the study. Only postmenopausal women will be included. Therefore, there is no risk of harm to an unborn fetus.

There also may be other side effects and/or risks that we cannot predict. You should tell the research staff about all the medications, vitamins and supplements you take and any

medical conditions you have. This may help avoid side effects, interactions and other risks.

Taking part in this research study may involve providing information that you consider confidential or private. Efforts, such as coding research records, keeping research records secure and allowing only authorized people to have access to research records, will be made to keep your information safe.

A Data Safety and Monitoring Committee, an independent group of experts, will be reviewing the data from this research throughout the study.

Are There Benefits to Taking Part in the Study?
If you agree to take part in this study, there may or may not be direct benefit to you. We hope the information learned from this study will benefit other people in the future. The benefits of participating in this study include receiving information about your risk factors for heart disease including cholesterol, blood pressure, blood sugar, body fat amount and location, and physical fitness status. These tests will help you to know how healthy you are compared to others your age and whether or not you have an immediate health concern. A possible benefit is that by losing weight and/or increasing your physical activity you may reduce your risk for diabetes and heart disease, and you may increase your muscle strength. Because individuals respond differently to diet and exercise, no one can know in advance if it will be helpful in your particular case.

What Other Choices Are There?
Classes and testing procedures similar to those offered in this study are available in the community and usually involve a charge to participants.

This is not a treatment study. Your alternative is to not participate in this study.

What about My Health Information?
In this research study, any new information we collect from you about your health or behaviors is considered Protected Health Information. The information we will collect for this research study includes**:** health history, your family health history, how you respond to study activities or procedures, laboratory and other test results, medical images, and information from study visits, phone calls, surveys, and physical examinations.

If this research study involves the diagnosis or treatment of a medical condition, then Protected Health Information collected from you during this study may be placed in your medical record, and may be used to help treat you, arrange payment for your care, or assist with Medical Center operations.

We will make every effort to keep your Protected Health Information private. We will store records of your Protected Health Information in a cabinet in a locked office or on a password protected computer. Only the following people or organizations will be granted access to your Protected Health Information:

1) The study investigator and his/her staff, or others at Wake Forest University Health Sciences who oversee research
2) Other people or laboratories providing services for this research project on behalf of Wake Forest University Health Sciences and Wake Forest University Baptist Medical Center

If required by law or court order, we might also have to share your Protected Health Information with a judge, law enforcement officer, government agencies, or others. If your Protected Health Information is shared with any of these groups it might no longer be protected by federal or state privacy rules.

Any Protected Health Information collected from you in this study that is maintained in the research records will be kept for at least six years after the study is finished. At that time any research information not already in your medical record will either be destroyed or it will be de-identified and any research information entered into your medical record will be kept for as long as your medical record is kept by the Medical Center. You will not be able to obtain a copy of your Protected Health Information in the research records until all activities in the study are completely finished.

You can tell Barbara Nicklas, PhD that you want to take away your permission to use and share your Protected Health Information at any time by sending a letter to this address:

Barbara Nicklas, PhD
Section on Gerontology and Geriatric Medicine
J. Paul Sticht Center on Aging
Medical Center Blvd.
Winston Salem, NC 27157

However, if you take away permission to use your Protected Health Information you will not be able to be in the study any longer. We will stop collecting any more information about you, but any information we have already collected can still be used for the purposes of the research study.

By signing this form you give us permission to use your Protected Health Information for this study.

If you choose to participate in this study, your medical record at Wake Forest University Baptist Medical Center will indicate that you are enrolled in a clinical trial. Information about the research and any medications or devices you are being given as a participant may also be included in a special section of your medical record. This part of the medical record will only be available to people involved in the research study or persons treating you at this Medical Center. If you are not a patient at this Medical Center, a medical record will be created for you anyway to ensure that this important information is available to doctors in case of an emergency.

A description of this clinical trial will be available on http://www.ClinicalTrials.gov, as required by U.S. Law. This website will not include information that can identify you. At

most, the website will include a summary of the results. You can search this Web site at any time.

Laboratory test results and other medical reports created as a result of your participation in the research study may be entered into the computer systems of Wake Forest University Health Sciences and North Carolina Baptist Hospital. These will be kept secure, with access to this information limited to individuals with proper authority, but who may not be directly involved with this research study.

A North Carolina Baptist Hospital (NCBH) medical record will be created for all study participants. Information about your participation in the study will be placed in the NCBH medical record, along with any routine medical test results that were obtained at NCBH as part of this study.

What Are the Costs?
There are no costs to you for taking part in this study. All study costs, including meal replacements and procedures related directly to the study will be paid for by the study. Costs for your regular medical care, which are not related to this study, will be your own responsibility. You will receive a parking voucher that will cover the cost of parking for each of your visits to the Medical Center for assessment visits.

Will You Be Paid for Participating?
You will receive no payment or other compensation for taking part in this study.

Who is Sponsoring this Study?
This study is being sponsored by the National Institute on Aging. The sponsor is providing money or other support to Wake Forest University Health Sciences to help conduct this study. The researchers do not, however, hold a direct financial interest in the sponsor or the product being studied.

What Happens if You Experience an Injury or Illness as a Result of Participating in this Study?
Should you experience a physical injury or illness as a direct result of your participation in this study, Wake Forest University School of Medicine maintains limited research insurance coverage for the usual and customary medical fees for reasonable and necessary treatment of such injuries or illnesses. To the extent research insurance coverage is available under this policy the reasonable costs of these necessary medical services will be paid, up to a maximum of $25,000. Wake Forest University Baptist Medical Center holds the insurance policy for this coverage. It provides a maximum of $25,000 coverage for each claim and is limited to a total of $250,000 for all claims in any one year. The Wake Forest University School of Medicine, and the North Carolina Baptist Hospitals, Incorporated do not assume responsibility to pay for these medical services or to provide any other compensation for such injury or illness. Additional information may be obtained from the Medical Center's Director of Risk and Insurance Management, at (336) 716-3467.

If you are injured, the insurer may require information such as your name, social security number, and date of birth in order to pay for your care. This is because the insurer is required by law to report any payments made to cover the care of any persons who are members of a government insurance plan to the Department of Health and Human Services.

You do not give up any legal rights as a research participant by signing this consent form. For more information on medical treatment for research related injuries or to report a study related illness, adverse event, or injury you should call Barbara Nicklas, PhD at 336-713-8584 during normal business hours and at 336-713-8250 Please identify yourself as an I'M FIT study participant.

What Are My Rights as a Research Study Participant?

Taking part in this study is voluntary. You may choose not to take part or you may leave the study at any time. Refusing to participate or leaving the study will not result in any penalty or loss of benefits to which you are entitled. If you decide to stop participating in the study we encourage you to talk to the investigators or study staff first to learn about any potential health or safety consequences. The investigators also have the right to stop your participation in the study at any time. This could be because it is in your best medical interest, your condition worsened, new information becomes available, you had an unexpected reaction, you failed to follow instructions, or because the entire study has been stopped.

You will be given any new information we become aware of that would affect your willingness to continue to participate in the study.

WHOM DO I CALL IF I HAVE QUESTIONS OR PROBLEMS?

For questions about the study or in the event of a research-related injury, contact the study investigator, Barbara Nicklas, PhD at 336-713-8584 during normal business hours and at 336-713-8250 Please identify yourself as an I'M FIT study participant.

The Institutional Review Board (IRB) is a group of people who review the research to protect your rights. If you have a question about your rights as a research participant, you should contact the Chairman of the IRB at (336) 716-4542.

You will be given a signed copy of this consent form.

We can send copies of your test results to your personal physician if you request it. Even if you do not wish to have any of your medical information sent to your physician, you can still participate in this research study. Do you request that we send important medical findings from your study tests/exams to your personal physician?

[ ] Yes [ ] No _____ Initials

Signatures

I agree to take part in this study. I authorize the use and disclosure of my health

information as described in this consent and authorization form. If I have not already received a copy of the Privacy Notice, I may request one or one will be made available to me. I have had a chance to ask questions about being in this study and have those questions answered. By signing this consent and authorization form, I am not releasing or agreeing to release the investigator, the sponsor, the institution or its agents from liability for negligence.

Subject Name (Printed):_____

Subject Signature: _____ Date: _____ Time: _____ am pm

Person Obtaining Consent: _____ Date: _____ Time: _____ am pm

Appendix B

I'M FIT Medical History

Acrostic _____ **SV1**

ID _____ Date: ___/___/___

Body System	**Yes**	**No**	**Start Date 1 (mm/yr)**	**Stop Day 1 or Cont**	**Start Date 2 (mm/yr)**	**Stop Date2 or Cont**	**Detail**
HEENT							
Glaucoma/Cataracts							
Hearing Problems							
Oral surgery							
Glasses/ Contacts							
Cardiovascular							
Heart Attack/ MI							
Stents							
Balloon Angioplasty							
Angina/Chest Pain							
Atrial Fibrillation							
Valvular heart disease							
Edema							
Hypertension							
Congestive Heart Failure							
Heart Murmur							
Irregular Heartbeat/Palpitations							
Blood clots/clotting disorders							
Respiratory							
Shortness of Breath							
COPD/ Emphysema							
Bronchitis/pneumonia							
Asthma							
Sleep Apnea/Loud Snoring							
Gastrointestinal							
Irritable Bowel Syndrome							
Stomach ulcers							
Blood in stool							
Gallstones/ Gallbladder Problems							
Heartburn							
Body System	**YES**	**NO**	**START DATE 1 (mm/yr)**	**STOP DATE 1**	**START DATE 2 (mm/yr)**	**STOP DATE 2**	**DETAILS**

				or CONT		or CONT	
Reflux							
Colon polyps							
Belching/Burping							
Hemorrhoids							
Diarrhea							
Hernia							
Renal/ Genitourinary							
Chronic renal failure							
Urinary Incontinence							
Recurrent Urinary Tract Infections							
Last Menstrual Period							
Enlarged Prostate							
Endocrine/ Metabolic							
Diabetes							
Thyroid Problems							
Gout							
High Triglycerides							
High Cholesterol							
Blood							
Anemia							
Musculoskeletal/ Skin							
Arthritis/ joint pain							
Chronic back pain							
Bursitis/ tendonitis							
Broken bones							
Osteopenia/Osteoporosis							
Joint replacement							
Body System	**YES**	**NO**	**START DATE 1 (mm/yr)**	**STOP DATE 1 or CONT**	**START DATE 2 (mm/yr)**	**STOP DATE 2 or CONT**	**DETAILS**
Neurologic/ Psychiatric							
Headaches							
Migraines							
Stroke/TIA							
Seizures							
Depression							
Anxiety							
Trouble Sleeping							

Alcohol Intake							
Substance Abuse							
Other							
Cancer							
Allergies							
Lidocain or Novocain							

Surgeries/ Hospitalizations	**Date (mm/yr)**

Coordinator's Signature_____ Date _____/_____/_____

Medical Director's Signature_____ Date _____/_____/_____

Appendix C

I'M FIT Demographics

Acrostic _____ **Visit: SV1**

ID _____ Interviewer _____ Date: ___/___/___

1. **What is your date of birth?** _____/_____/_____
   MMM DD YYYY

2. **What is your sex?** Male ☐ Female ☐

3. **What do you consider your ethnic origin to be?**

   ☐ African American/Black ☐ Hispanic or Latino
   ☐ Multiracial or Other ☐ Caucasian/White
   ☐ American Indian or Alaska Native
   ☐ Asian ☐ Native Hawaiian or Pacific Islander

4. **Do you live alone?** Yes ☐ No ☐ Refused ☐

   Yes → Go to Question #7
   No → Go to Question #5
   Refused → Go to Question #5

5. **Who lives with you? Mark all that apply:**

   Spouse ☐ Child ☐ Friend ☐ Other Relative ☐ Paid Employee ☐ ☐
   Other: _____ Refused

6. **Including yourself, how many live in your household?** _____ ☐
   Refused

7. **Which of the following best describes your current marital status?**

   Married ☐ Separated ☐ Divorced ☐ Widowed ☐
   Never Married ☐ Other _____ ☐ Refused ☐

8. **What was the last grade you completed in school?**

   No Formal Education (00) ☐ College (13-16) ☐
   Refused ☐

Elementary School (K-08) ☐ Post Graduate ☐

High School/Equivalent (09-12) ☐ Other: ☐

Appendix D

I'M FIT Vital Signs

Acrostic _____ **Visit:**
SV1
ID _____ Date: ___/___/___
Interviewer _____

Vital Signs:

Pulse _____bpm

Height: _____ cm Weight: _____kg

BMI: _____

Sex

Male ☐ Female ☐

Women: BMR = 655 + (9.6 x weight in kilos) + (1.8 x height in cm) - (4.7 x age in years)

Men: BMR = 66 + (13.7 x weight in kilos) + (5 x height in cm) - (6.8 x age in years)

Caloric Equation: _____

Sitting Blood Pressure (after 5 minutes of rest)

Arm: Right ☐ Left ☐ (Explain I left, _____)

Cuff size: ☐ Regular

☐ Large

☐ Thigh

_____/_____ mmHg
Systolic/Diastolic

Comments:
_____

Appendix E

I'M FIT Biodex Protocol

Acrostic _____ **Visit: SV2 SV3 FV1**

ID_____ Date: ___/___/___

Interviewer _____

Did the participant complete a walking warm- up? Yes No

Weight: _____kg Blood pressure: _____ **Exclude if >199/109 mmHg**

Which is the participant's dominant leg? Right Left

If any of the below responses are "Yes," do not test.

Has the doctor ever told you that you have an aneurysm in the brain? Yes No

Has the doctor ever told you that you had a cerebral hemorrhage or bleeding in your brain in the last 6 months? Yes No

If any of the below responses are "Yes," do not test. Proceed testing on other leg.

Have you ever had knee surgery on either leg where all or part of the joint was replaced?
Yes No

Is it difficult for you to bend or straighten either of your knees fully due to pain, arthritis, injury, or some other condition? Yes No

Chair settings

a. Dynamometer tilt	0	e. Chair height	
b. Dynamometer rotation	90^0	f. Chair depth	
c. Dynamometer right		g. Chair angle	85^0
d. Dynamometer left		h. T depth	
		i. Attach arm length	

Perform Manual Test
Did you have pain in your knee that stopped you from pushing hard?
Yes No

"Please hold onto the chest straps. Remember to breathe throughout the test. Should you experience any pain please let me know immediately."

Right leg
Trials: **"I'd like you to feel the range of motion. Slowly, push and pull against the lever arm until it stops. Go ahead and do this a few times to get familiar with the machine. How hard was that for you?** (show RPE scale) **This time, when you push and pull against the lever arm, do so somewhere in the green zone. I'd like for this to be somewhat hard.** (participant does 3

trials at a moderate RPE) **Did you experience any pain?** Rest. If no, proceed with testing. If yes, rest and see if the participant wants to continue.

Trial 1 at 60^0: "For this trial I'd like for you to push and pull as hard as you can against the lever arm until it stops. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)

60°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 1 at 60^0:_____Nm _____Nm _____Nm _____Nm

Trial 2 at 60^0: "Now we'll let you rest." Rest 90 seconds. **"We are going to do that again. I'd like for you to push and pull as hard as you can against the lever arm until it stops. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)**

60°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 2 at 60^0:_____Nm _____Nm _____Nm _____Nm

"Now we'll let you rest." Rest 90 seconds. **"Now we are going to change speeds. To get a better understanding of how it feels, I'd like you to slowly, push and pull against the lever arm until it stops. Go ahead and do this a few times to get use to the machine. How hard was that for you?** (show RPE scale) **This time, when you push and pull against the lever arm, do so somewhere in the green zone. I'd like for this to be somewhat hard.** (participant does 3 trials at a moderate RPE) **Did you experience any pain?** Rest. If no, proceed with testing. If yes, rest and see if the participant wants to continue.

Trial 3 at 240^0: "This trial I'd like for you to push and pull as hard as you can against the lever arm until it stops. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)

240°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 3 at 240^0:_____Nm _____Nm _____Nm _____Nm

Trial 4 at 240^0: "Now we'll let you rest." Rest 90 seconds. **"We are going to do that again. Whenever you are ready I'd like for you to push and pull against the lever arm until it**

stops. Continue to do this until I say stop. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)

240°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 4 at 240^0:_____Nm _____Nm _____Nm _____Nm

Switch to Left leg
Perform Manual Test
Did you have pain in your knee that stopped you from pushing hard?
Yes No

Trials: **"Slowly, I'd like for you to push and pull against the lever arm until it stops. Do this a few times to get use to the machine. How was that for you?** (show RPE scale) **This time, I'd like for you to push and pull against the lever arm. I'd like for you to work in the green zone, or for this to be somewhat hard.** (participant does 3 trials at a moderate RPE) **Did you experience any pain?** If no, proceed with testing. If yes, rest and see if the participant wants to continue.

Trial 6 at 60^0: "This next trial I'd like for you to push and pull as hard as you can against the lever arm until it stops. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)

60°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 6 at 60^0:_____Nm _____Nm_____Nm _____Nm

Trial 7 at 60^0: "Now we'll let you rest." Rest 90 seconds. **"We are going to do that again. Whenever you are ready I'd like for you to push and pull against the lever arm until it stops. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)**

60°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 7 at 60^0:_____Nm _____Nm _____Nm _____Nm

"Now we'll let you rest." Rest 90 seconds. **"Now we are going to change speeds. To get a better understanding of how it feels, I'd like you to slowly, push and pull against the lever**

arm until it stops. Go ahead and do this a few times to get use to the machine. How hard was that for you? (show RPE scale) **This time, when you push and pull against the lever arm, do so somewhere in the green zone. I'd like for this to be somewhat hard.** (participant does 3 trials at a moderate RPE) **Did you experience any pain?** Rest. If no, proceed with testing. If yes, rest and see if the participant wants to continue.

Trial 8 at 240^0: This next trial I'd like for you to push and pull as hard as you can against the lever arm until it stops. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)

240°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 8 at 240^0:_____Nm _____Nm _____Nm _____Nm

Trial 9 at 240^0: "Now we'll let you rest." Rest 90 seconds. **"We are going to do that again. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)**

240°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 9 at 240^0:_____Nm _____Nm _____Nm _____Nm

Trial 8 at 240^0:_____Nm _____Nm _____Nm _____Nm

Trial 9 at 240^0: "Now we'll let you rest." Rest 90 seconds. **"We are going to do that again. Continue to do this until I say stop. Whenever you are ready, you may begin." (PROMPT PUSH/PULL respectively)**

240°/sec	AWY	TWD
Peak Torque		
Total Work		
% CV		

Trial 9 at 240^0:_____Nm _____Nm _____Nm _____Nm

Appendix F

I'M FIT
Short Physical Performance Battery

Acrostic _____ **Visit: SV1 FV2**

ID _____ Date: ___/___/___

Interviewer: _____

All of the tests should be performed in the same order as they are presented in this protocol. Instructions to the participant are shown in bold and should be given exactly as they are written in this script.

Test is being completed in the research center (GRC) ☐ **clinic (G floor)**

I would now like you to try to move your body in different movements. I will first describe and show each movement to you. Then I'd like you to try to do it. If you cannot do a particular movement, or if you feel it would be unsafe to try to do it, tell me and we'll move on to the next one. Let me emphasize that I do not want you to try to do any movement that you feel might be unsafe. Do you have any questions before we begin?

Balance Tests

The participant must be able to stand unassisted without the use of a cane or walker. You may help the participant to get up.

Side-by-Side

Now I will show you the first movement. *(Demonstrate)* **I want you to try to stand with your feet together, side-by-side, for about 10 seconds. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop.** *Stand next to the participant to help him/her into the side-by-side position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant has his/her feet together, ask* **"Are you ready?"** *Then let go and begin timing as you say,* **"Ready, begin."** *Stop the stopwatch and say* **"Stop"** *after 10 seconds or when the participant steps out of position or grabs your arm. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test.*

Side-by-Side

Score

☐ Held 10 sec SCORE = 1. Go to Semi-tandem balance test.

_____

☐ Held < 10 sec SCORE = 0. Go to gait speed test.

☐ Not attempted; state reason _____SCORE = 0. Go to gait speed test

Number sec held if < 10 ___.___

Semi-Tandem Stand

Now I will show you the second movement. *(Demonstrate)* **I want you to try to stand with the side of the heel of one foot touching the big toe of the other foot for about 30 seconds. You may put either foot in front, whichever is more comfortable for you. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop.** *Stand next to the participant to help him/her into the semi-tandem position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant has his/her feet positioned, ask* **"Are you ready?"** *Then let go and begin timing as you say,* **"Ready, begin."** *Stop the stopwatch and say* **"Stop"** *after 30 seconds or when the participant steps out of position or grabs your arm. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test.*

Semi-Tandem Stand
Score

☐ Held 30 sec SCORE = 1. Go to tandem stand test. _____

☐Held ≥ 10 but < 30 sec SCORE = 1. Number of sec held ____.____ Go to tandem stand test.

☐Held < 10 sec SCORE = 0. Number of sec held ____.____ Go to gait speed test.

☐Not attempted; state reason _____ SCORE = 0. Go to gait speed test.

Tandem Stand

Now I will show you the third movement. *(Demonstrate)* **I want you to try to stand with the heel of one foot in front of and touching the toes of the other foot for about 30 seconds. You may put either foot in front, whichever is more comfortable for you. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop.** *Stand next to the participant to help him/her into the tandem position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant has his/her feet positioned, ask* **"Are you ready?"** *Then let go and begin timing as you say,* **"Ready, begin."** *Stop the stopwatch and say* **"Stop"** *after 30 seconds or when the participant steps out of position or grabs your arm.*

Tandem Stand

Trial 1
Score

☐ Held 30 sec SCORE = 2. Go to 1 leg stand test. _____

☐Held 10 – 29.99 sec, go to trial 2. SCORE = 2. Number of sec held ____.____

☐Held 3 – 9.99 sec, SCORE = 1. Go to trial 2. Number of sec held ____.____

☐Held < 3 sec or unable to attain position SCORE = 0. Go to gait speed test.

☐ Not attempted SCORE = 0. State reason below. Go to gait speed test.

Trial 2

☐ Held 30 sec, go to 1 leg stand test.

☐Held 0 – 29.99 sec, go to gait speed test. Number of sec held ___.___

☐ Not attempted. State reason below. Go to gait speed test.

If participant did not attempt or complete test, circle the letter which corresponds to the reason:

a. Tried, but unable

b. Participant could not hold position unassisted

c. Not attempted, you felt unsafe

d. Not attempted, participant felt unsafe

e. Participant unable to understand instructions

f. Other (specify) _____

One Leg Stand

Now I will show you the fourth movement. *(Demonstrate)* **I want you to try to stand on one leg for about 30 seconds. You may stand on either leg, whichever is more comfortable for you. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your foot. Try to hold this position until I tell you to stop. If you lose your balance, put your foot down.** *Stand next to the participant to help him/her into the side-by-side position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant has his/her leg lifted, ask* **"Are you ready?"** *Then let go and begin timing as you say,* **"Ready, begin."** *Stop the stopwatch and say* **"Stop"** *after 30 seconds or when the participant lowers leg to the floor or grabs your arm.*

One Leg Stand

Trial 1

☐ Held 30 sec. Go to gait speed test.

☐Held 1 – 29.99 sec. Go to trial 2. Number sec held ___.___

☐Held < 1 sec or unable to attain position. Go to gait speed test.

☐ Not attempted, state reason below. Go to gait speed test.

Trial 2

☐ Held 30 sec. Go to gait speed test.

☐Held 1 – 29.99 sec. Go to gait speed test. Number of sec held ____.____

☐Held < 1 sec or unable to attain position, go to gait speed test.

☐ Not attempted, state reason below. Go to gait speed test.

If participant did not attempt or complete test, circle the letter which corresponds to the reason:

a. Tried, but unable
b. Participant could not hold position unassisted
c. Not attempted, you felt unsafe
d. Not attempted, participant felt unsafe
e. participant unable to understand instructions
f. Other (specify) _____

Total Balance Tests Score *(sum points: possible range is 0 to 4)*

_____

Gait Speed Test (4 meters)

First Gait Speed Test

Now I am going to observe how you normally walk. If you use a cane or other walking aid and you feel you need it to walk a short distance, then you may use it. This is our walking course. I want you to walk to the other end of the course at your usual speed, just as if you were walking down the street to go to the store. *Demonstrate the walk for the participant.* **Walk all the way past the other end of the tape before you stop. I will walk with you. Do you feel this would be safe?** *Have the participant stand with both feet touching the starting line*. **When I want you to start, I will say: "Ready? Begin."** *When the participant acknowledges this instruction say:* **"Ready? Begin."** *Press the start/stop button to start the stopwatch when the participant steps over the starting line. Walk behind and to the side of the participant. Stop timing when one of the participant's feet is completely across the end line.*

Time for first 4 meter walk (seconds)

___.___

Aids used for first walk:

a. None **b.** Cane **c.** Other (specify)

_____

If participant did not attempt test, circle the letter which corresponds to the reason and go to the Chair Stand Test.

a. Tried, but unable
b. Participant could not walk unassisted
c. Not attempted, you felt unsafe
d. Not attempted, participant felt unsafe

e. Participant unable to understand instructions
f. Other (specify) _____

Second Gait Speed Test

Now I want you to repeat the walk. Remember to walk at your usual pace, and go all the way past the other end of the course. *Have the participant stand with both feet touching the starting line. When I want you to start, I will say*: **"Ready? Begin."** *When the participant acknowledges this instruction say:* **"Ready? Begin."** *Press the start/stop button to start the stopwatch when the participant steps over the starting line. Walk behind and to the side of the participant. Stop timing when one of the participant's feet is completely across the end line*.

Time for second 4 meter walk (seconds)

___.___

Aids used for second walk:

a. None **b.** Cane **c.** Other (specify)
_____

If participant did not attempt test, circle the letter which corresponds to the reason and go to the Chair Stand Test.

a. Tried, but unable
b. Participant could not walk unassisted
c. Not attempted, you felt unsafe
d. Not attempted, participant felt unsafe
e. Participant unable to understand instructions
f. Other (specify) _____

Interviewer note: What is the time (sec) for the faster of the two walks?

Record the lesser of the two times. (If only 1 walk done, record that time.)

___.___

4 Meter Walk
Score

Unable to do the walk SCORE = 0 Time 4.82 to 6.20 sec SCORE = 3

Time > 8.7 sec SCORE = 1 Time < 4.82 sec SCORE = 4 _____

Time 6.21 to 8.7 sec SCORE = 2

Narrow Walk Test

Now I am going to observe how you walk keeping your feet inside the lines. I want you to walk to the other end of the course at your usual speed. It is important that you do your best

to keep your feet inside the lines. *Demonstrate the walk for the participant.* **Be sure to walk a few steps past the finish line. I will walk with you. Do you feel this would be safe?** *Have the participant stand with both feet touching the starting line*. **When I want you to start, I will say: "Ready? Begin."** *When the participant acknowledges this instruction say:* **"Ready? Begin."** *Press the start/stop button to start the stopwatch when the participant steps over the starting line. Walk behind and to the side of the participant. Stop timing when one of the participant's feet is completely across the end line.*

Did the participant stay within the lines?

("Not staying within the lines" is defined as stepping on, or going outside of the colored tape two or more times. Perform up to 3 trials to obtain 2 valid times.)

Trial 1 ____Yes ☐☐.☐☐ seconds ____No

Trial 2 ____Yes ☐☐.☐☐ seconds ____No

Trial 3 ____Yes ☐☐.☐☐ seconds ____No

If participant did not attempt test, circle the letter which corresponds to the reason and go to the Chair Stand Test.

a. Tried, but unable
b. Participant could not walk unassisted
c. Not attempted, you felt unsafe
d. Not attempted, participant felt unsafe
e. Unable to understand instructions
f. Other (specify)

_____

Chair Stand Test

Let's do the last movement test. Do you think it would be safe for you to try to stand up from a chair? The next test measures the strength in your legs. *(Demonstrate and explain the procedure.)* **First, fold your 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 across your chest.** *(Record result.) If the participant cannot rise without using arms, say* "**Okay, try to stand up using your arms.**" *This is the end of the test. Record result onto the scoring page.*

Single Chair Stand Test Questions

Does the participant feel safe enough to stand without help? YES NO

Results: Circle the letter that corresponds to the result.

a. Participant stood without using arms (Go to repeated chair stand test).

b. Participant used arms to stand (End test; score as 0 points, and answer the following question.)

c. Test not completed (End test; score as 0 points, and answer the following question.)

If participant did not attempt test or failed, circle the letter which corresponds to the reason.

a. Tried, but unable
b. Participant could not stand up unassisted
c. Not attempted, you felt unsafe
d. Not attempted, participant felt unsafe
e. Participant unable to understand instructions
f. Other (specify) _____
g. Participant refused

Repeated Chair Stand Test

Do you think it would be safe for you to try 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'll be timing you with a stopwatch.** *When the participant is properly seated, say:* **"Ready? Stand."** *Begin timing. Count out loud as the participant arises each time, up to five times. Stop if participant becomes tired or short of breath during repeated chair stands. Stop the stopwatch when he/she has straightened up completely for the fifth time.*

Also stop if participant uses his/her arms, after 1 minute, if participant has not completed all 5 rises, or at your discretion, if concerned for participant's safety. If the participant stops and appears to be fatigued before completing the five stands, confirm this by asking **"Can you continue?"**

Repeated Chair Stand Test Questions

Does the participant feel safe enough to stand without help?
YES NO

Time (sec) to complete 5 stands (only enter if participant completes 5 stands)
____.____

If participant did not attempt test or failed, circle the letter which corresponds to the reason.

a. Tried, but unable
b. Participant could not stand up unassisted
c. Not attempted, you felt unsafe
d. Not attempted, participant felt unsafe
e. Unable to understand instructions
f. Other (specify)
g. Participant refused

Chair Stand
Score

Participant unable to complete 5 chair stands or completes in > 60 sec SCORE = 0

Time $\geq$ 16.70 sec SCORE = 1

Time 13.70 to 16.69 sec SCORE = 2

Time 11.20 to 13.69 sec SCORE = 3

Time ≤ 11.19 sec SCORE = 4

_____

Scoring for Complete Short Physical Performance Battery

Total Balance Test score

_____

Gait Speed Test score _____

Chair Stand Test score _____

Total Score

_____

Extended Scoring

Balance – Total the longest times held on semi-tandem, tandem, and one-leg stands. Divide by 90. Highest score = 1.

Longest time held on **semi-tandem stand**

(if less than 30, there should be no other scores) _____

Longest time held on **tandem stand** _____

Longest time held on **one-legged stand** +_____

_____

Total Score (maximum is 90) _____ / 90 = _____

Walk Speed - Distance is divided by the faster walk time to get speed in m/s. Divide the speed by 2 m/s, which is thought to be the fastest possible walking speed. Highest score = 1.

4m/ _____ s = _____/2 = _____

Narrow Walk- Distance is divided by the faster walk time to get speed in m/s. Divide the speed by 2 m/s

4m/ _____ s = _____/2 = _____

Repeated Chair Stands – Divide the number of stands by the time. If unable to do the test, score = 0. Highest score = 1, even if test is completed in less than 5 seconds.

5/ _____s = _____

Total Extended Score – Add 4 sub-scores. Highest score = 4. TOTAL =_____

Appendix G

Acrostic _____ **I'M FIT 400 Meter Walk** **Visit: SV2 FV2**

ID _____ Date: ___/___/___

Interviewer: _____

400 Meter Walk

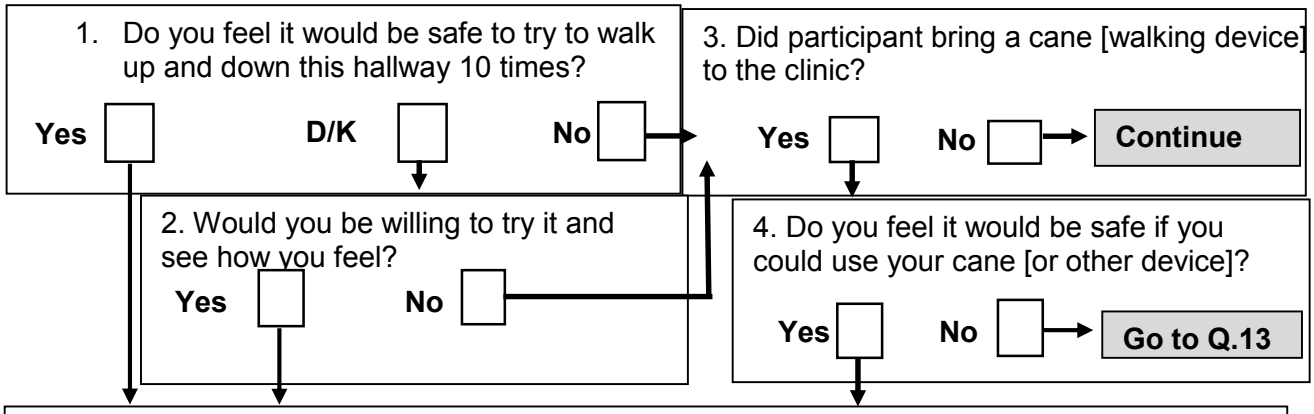
Stopping Criteria for 400 Meter Walk: If the participant reports chest pain, tightness or pressure, significant shortness of breath or difficulty breathing, or feeling faint, lightheaded or dizzy, stop the test. Record the reason for stopping.

OBSERVATIONS OF 400 METER WALK

Accompany the subject to the starting line of the 400 meter walk with script and stop watch. Describe the 400 meter walk:

Script: **"You will be walking 10 complete laps around the course, which corresponds to about ¼ mile. I would like you to walk as quickly as you can, without running, at a speed you can maintain for 10 laps. If you develop chest pain or significant shortness of breath, or are too uncomfortable to continue, please stop walking and tell me. If you need to, you may stand in place and rest for a few moments.**

If subject uses cane or other assistive device: **"I would like you to attempt this test without your cane (or other walking device)."**



Script:" I will demonstrate 1 lap." *After completing demonstration, ask:* **"Do you have any questions?"**

When subject indicates they feel ready to begin, the test may proceed:

Script: **"I will walk behind you. When I say 'GO", start *walking* as quickly as you can.**

Start the stop watch when the subject takes their first step. For safety purposes, examiner should follow subject at a reasonable distance during test. Examiner should be close enough to subject to be able to provide help should subject falter during test, but not so close as to dictate the pace of the test. The examiner should be behind and to the side of the subject, just outside their peripheral vision. For every lap, the examiner should offer standard encouragement, and call out the number of laps completed and number remaining.

Script: **"You're doing a good job. You have completed __ laps and have __ to go."**

If the participant feels they need to stop and rest, they may stand in one place and rest. Participant should not lean on wall, table or elsewhere. After 30 seconds, ask them if they can continue walking. If they can, continue the walk and note the rest on the form. (go on to #6)

If the participant appears to be in obvious distress or pain, you may recommend that he/she stand in place and rest for a moment. If they need to rest longer, have them continue to stand. After another 30 seconds, ask them if they can continue walking. If they can, continue the walk and note the rest stop on the form. (go on to #6)

If they cannot continue after a 60 second rest or if they need to sit down, stop the test.

(go on to #7)

4. a. Did the participant use an assitive walking device during the test? Yes ☐ No ☐

5. Mark an X in the corresponding box when each lap is completed.

Lap 1	Lap 2	Lap 3	Lap 4	Lap 5
☐	☐	☐	☐	☐

Lap 6	Lap 7	Lap 8	Lap 9	Lap 10
☐	☐	☐	☐	☐

6. For each rest stop, Mark an X corresponding to the length of time of the rest (standing rests only):

	< 30 sec.	31-60 sec.	> 60 seconds (test stopped)
Rest stop number 1:	☐	☐	☐
Rest stop number 2:	☐	☐	☐
Rest stop number 3:	☐	☐	☐
Rest stop number 4:	☐	☐	☐
Rest stop number 5:	☐	☐	
Rest stop number 6:	☐	☐	
Rest stop number 7:	☐	☐	☐
Rest stop number 8:	☐	☐	☐
Rest stop number 9:	☐		
Rest stop number 10:	☐		

Total number of stops: ☐☐

7. *If the test is terminated <u>prior to the subject completing 400 meters,</u> the point at which they stopped should be marked, and the subject accompanied to the nearest chair. After the subject is comfortably seated, their accomplished distance should be measured.*

Complete laps will be counted as 40 meters and the remaining incomplete lap should be accurately measured as described below. Record the total distance and time at termination of test.

If the participant stopped in the first half of the lap (after leaving the starting cone but before getting to the distant cone) then measure the distance from the starting cone to where they stopped. If the participant stopped in the second half of the lap (after leaving the distant cone but before getting back to the starting cone) then measure the distance from the distant cone to the stopping point and add 20 meters.

Number of meters completed: ☐☐☐ M

Yes ☐ **No** ☐ →

8. TIME to walk 400 meters or to stopping the test: ☐☐ Minutes ☐☐ Seconds

9. Sitting Radial Pulse: beats per 30 seconds X2 ☐☐☐ bpm

10. If test stopped early, ask: **"Why did you feel you couldn't continue?"**

Shortness of Breath	☐	Feeling Faint or Dizzy	☐
Chest Pain	☐	Fatigue	☐
Leg Pain	☐	Other: (Specify) _____	☐

11. At end of walk ask, **"Is there anything bothering you?"** **Yes** ☐ **No** ☐

If yes, please specify what: _____

12. Observed Symptoms at end of walk: (X all that apply)

Shortness of breath	☐	Unsteadiness	☐	Other: _____	☐
Wheezing / dyspnea	☐	Sweating	☐	No symptoms observed	☐
Signs of discomfort	☐				

13. Comments: _____

_____

CURRICULUM VITA

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OBJECTIVE

- To earn a Ph. D. in Exercise Science and specialize in Biomechanics.

EDUCATION

Wake Forest University, Winston-Salem NC
May 2014
Master of Science in Health & Exercise Science
Thesis: "Whole Muscle and Fiber Type and Lower Body Physical Performance in Overweight and Obese Older Adults"
GPA: 3.25

The College at Brockport State University of New York, Brockport NY
May 2012
Bachelor of Science in Kinesiology with Honors
Thesis: "Effects of Plyometric Training on Time-Course Adaptations to Tendons Properties"
GPA: 3.65

Erie Community College State University of New York, Orchard Park NY
September 2008
Physical Education with Honors
GPA: 3.89

RESEARCH EXPERIENCE

Wake Forest University Department of Health and Exercise Science August 2012-Present

- *Research Assistant,* Improving Muscle for Functional Independence Trial (IMFIT).
  - Collaborated with the study investigators to develop procedures used to analyze research data
  - Directly responsible for processing, organization and presentation the primary outcome data.
  - Determined MAT Lab procedures to process muscle strength data.
  - Programmed code in MAT Lab that assisted in data analysis.
  - Performed statistical analysis of research data.
- *Interventionist,* The Effects of Beet Root Juice and Exercise on Hypertension in Older Adults
  - Conducted graded exercise testing in sample population before and after the intervention.
  - Composed reports for incidents that occurred during the intervention.
  - Organized and managed the interventionist's schedule for training sessions
  - Communicated with fellow research staff to assistant in scheduling of participant visits
  - Performed exercising blood pressure assessments during each training session.

The College at Brockport, State University of New York Spring 2009- Spring 2012

- *Research Grant*
  - A competitive grant given to a select number of applicants
  - Directly responsible for daily operation, data collection, research, athlete training and supervision of the biomechanics lab.
- *Independent Study,* Biomechanics of Power Training
  - Conducted training sessions for university athletes on multi-joint isokinetic dynamometer.
  - Researched theory on power training and isokinetics
- *Internship,* Biomechanics Lab
  - Instructed independent study students in isokinetic research, along with designing biomechanics related research projects.
- *Investigator,* Study on Lower Cross Syndrome
  - This study investigates the theory of lower cross syndrome and the relationship between recruitment patterns at its association with lower back discomfort.
- *Isokinetic Case Study,* Biomechanics Lab
  - Developed protocols for multi-joint isokinetic exercises by applying theoretical framework.
  - Training of athletes on an isokinetic dynamometer and adjusting the program when necessary.

HONORS AND AWARDS

Graduate Scholarship – Wake Forest University 2012-2014
Phi Epsilon Kappa – Exercise Science Honor Society 2010
Kappa Delta Pi - International Honor Society for Teaching Professionals 2010
Eagle Scout - Troop 410 West Seneca, NY 2006

PROFESSIONAL EXPERIENCE

HES 101 Exercise for Health, Department of Health & Exercise Science August 2012-Present

- *Assistant Coordinator*
  - Developed an updated the HES 101 curriculum including lectures, labs, exams and course materials.
  - Presented HES 101 course lectures, labs, exams and course material to fellow graduate students, preparing them to instruct their individual classes.
  - Collaborated with health and exercise science faculty to address exercise science principles discussed that are discussed in the course.
- *Lecturer*
  - Instructed three sections of a half-semester introductory course in health and exercise science.
  - Present lectures on topics relevant to different components of health and fitness such as, how to assess personal fitness, cardiovascular fitness, muscular fitness, and flexibility
  - Supervise labs that reinforce the topics covered in lecture
  - Grade quizzes, personal exercise programs, and final exams

Healthy Exercise and Lifestyle Program August 2012 – August 2013

Staff Member

- Developed experience in clinical health care, primarily with older adults, most of whom were afflicted by some type of chronic disease(s)
- Monitored blood pressure and ECG rhythms on patients at rest and during graded exercise

testing
- Collaborated to develop individualized exercise prescriptions for participants that addressed their comorbidities, risk factors and personal goals
- Conducted fitness assessments on patients used to determine their exercise prescriptions

Physical Education Teaching
- 210 hours experience at the secondary and elementary level, planning and teaching.

TECHNICAL SKILLS

Exercise Prescription & Program Development
- Blood Pressure Monitoring
- Graded Exercise & Metabolic Testing
- Force Transducers
- Force Platforms
- Excel Macros
- MAT Lab
- Wingate cycle test
- Margaria Kalamen test
- Isokinetic Dynamometry
- Vertical & broad jump evaluations
- Skinfold caliper assessment
- Indirect calorimetry
- Video Analysis
- Goniometry
- Electrogoniometry
- Cardiac Rhythm Identification
- Proficient in IBM SPSS Statistics software

CERTIFICATIONS

NYS Teacher Certification Examinations
- Liberal Arts and Sciences (LAST)
- Assessment of Teaching Skills-Writing (ATS-W)
- Content Specialty Test in Physical Education (CST)

CPR/AED American Heart Association 2014

PROFESSIONAL ASSOCIATIONS

American College of Sports Medicine 2012 – Present
National Strength and Conditioning Associations 2013 – Present