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Muscle quality and relative adiposity are the strongest predictors of lower-extremity physical function in older women

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ABSTRACT

Objectives: The aim of this study was to examine the relative contributions of physical activity, adiposity, lean mass and muscle quality to lower-extremity physical function (LEPF) in older women.
Study design: Cross-sectional analysis at a university research laboratory.
Main outcome measures: : Community-dwelling older women ($n = 96$, 73.9 ± 5.6 years, BMI = 26.5 ± 4.7 kg/m^2) were assessed for body composition via dual-energy X-ray absorptiometry, leg extension power using the Nottingham power rig, muscle quality (W/kg) as the ratio of leg extension power (W) to lower-body mineral free lean mass (kg) and moderate-intensity physical activity via questionnaire. A composite measure of LEPF was calculated by summing Z-scores of the 6-min walk, 8-foot up-and-go and 30-s chair stand tests.
Results: Muscle quality and physical activity were associated with all measures of LEPF (all $p < 0.01$). Relative adiposity was related to the 6-min walk and 30-s chair stand (both $p < 0.01$); lower-body mineral-free lean mass was not related to any measure of LEPF ($p > 0.05$). Hierarchical linear regression analyses revealed that muscle quality (standardized $\beta = 0.47$, $p < 0.01$) and relative adiposity ($\beta = -0.33$, $p < 0.01$) were the strongest independent predictors of composite LEPF Z-score explaining 24% and 17% of the variance, respectively.
Conclusions: Muscle quality and relative adiposity are the strongest independent predictors of LEPF in older women. These findings suggest that maintaining muscle quality, especially relative to adiposity, may be a critical target for interventions to prevent declines in physical function in older women.

1. Introduction

The number of older adults (≥65 years) living in the United States was 43.1 million in 2012; however, it is estimated that this population will grow to79.7 million by 2040 [1]. Older women outnumber men, with 24.3 million older women (vs. 18.8 million older men) [1]. Notably, in 2011, the remaining life expectancy for a 65-year-old woman was 20.4 years [1]. Older women represent a subgroup of the aging population that may be particularly susceptible to declines in physical function. Relative to older men, women have lower physical activity levels [2], greater adiposity [3,4] and less lean mass [3,4], as well as lower muscle quality [5], all of which contribute to physical function. Maintaining physical function is paramount as it is a significant predictor of adverse health outcomes such as physical disability, institutionalization and mortality in older adults [6]. Therefore, characterizing the interplay of modifiable factors that impact physical function, such as physical activity, body composition and muscle quality, is a contemporary research interest [7].

The impact of body composition on physical function has been an active area of investigation in the older adult cohort due to a prominent age-related shift toward greater adiposity and lower lean mass, which is evident even in relatively healthy older adults [8]. However, findings regarding the relative importance of adiposity and lean mass for physical function have been inconsistent [9,10]. For example, Fantin et al. [9] reported that reduction in appendicular or leg fat-free mass was the main predictor of worsening disability in older men and women. Conversely, Zoico et al. [10] reported that high baseline fat mass, independent of appendicular fat-free mass, was significantly related to incidence of limitations in climbing stairs in women. Additionally, there is evidence that sex

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influences the relationship between adiposity and physical function [3,11], such that women are more adversely affected than men. Thus, better characterization of the importance of adiposity and lean mass for physical function in older women is needed.

Other studies have attempted to characterize the impact of muscle capacity (strength or power) on physical function in older adults. Both muscle strength [12] and power [13] are associated with physical function, but recent evidence suggests that power is potentially more impactful [14]. Muscle power is the product of contraction force and movement velocity [15], and thus represents an older adult's ability to generate force rapidly. Multiple studies have reported an association between muscle power and physical function in older adults, including gait speed [16], stair climbing performance [17], and self-reported functional status [13], underscoring its value as a predictor of function. However, these studies did not examine the importance of muscle power in the larger context of overall body composition (adiposity and lean mass), which is well-known to impact physical function in older adults [7]. In addition, muscle power was not normalized for muscle mass or cross-sectional area to provide an index of muscle quality (e.g., power per unit of muscle size).

In studies that have accounted for indices of body composition, the relationship between muscle quality and physical function has been equivocal [5,18,19]. Studies by Fragala et al. [5] and Bouchard et al. [18] did not observe a relationship between muscle quality and physical function in older women. However, both of these studies defined muscle quality using leg strength, and a growing body of evidence suggests that muscle power is more strongly associated with physical function than strength [13,20]. In addition, one study [18] included self-reported measures of physical function in a composite score, and neither study accounted for physical activity in their analyses. Thus, no study has reported the relative importance of muscle quality (defined using power), after accounting for measures of body composition (both adiposity and lean mass) and physical activity, for physical function in older women.

Despite extensive research, the strongest predictor of physical function in older adults remains unclear, and one explanation may be the lack of studies that have concurrently examined potential contributing factors (e.g., body composition, muscle quality and physical activity) in a single analysis. In this context, the purpose of the present study was to examine the relative contributions of physical activity, adiposity, lean mass and muscle quality to lower-extremity physical function (LEPF) in community-dwelling older women. Based on previous research [4,19], we hypothesized that muscle quality would be the strongest independent predictor of LEPF, but that relative adiposity would also have a significant association.

2. Methods

2.1. Participants

Community-dwelling women ($n = 96$, 73.9 ± 5.6 years) aged ≥ 65 years were recruited for participation. The present study is a secondary analysis of an existing data set from which we have previously reported on the functional capacity of community-dwelling older women [21]. Subjects were recruited via advertisements in newsletters, guest lectures, and flyers targeting local organizations of older adults. Exclusion criteria included uncontrolled cardiovascular, metabolic, musculoskeletal, or psychological conditions that would have precluded individuals from completing testing measures. Comorbidities were assessed via self-report using a questionnaire and included cardiovascular disease, pulmonary disease, arthritis, diabetes, osteoporosis, hypertension, peripheral vascular disease and other conditions (sleep apnea, cancer, and epilepsy). All participants provided written informed consent prior to enrollment and all procedures in this study were approved by the Institutional Review Board at the University of Georgia.

2.2. Body composition

Standing height and weight were measured with participants wearing light-weight clothing and no shoes. Height was obtained using a stadiometer (Seca, Model 242) with measures obtained to the nearest 0.1 cm. Weight was measured on a calibrated digital scale (Tanita, Model WB-110A). Whole-body and regional soft tissue composition (relative adiposity and mineral-free lean mass) was assessed via dual-energy X-ray absorptiometry (iDXA, GE Healthcare-Luna, Madison, WI). Lower-body mineral-free lean mass was quantified as total mineral-free lean mass below the superior border of the iliac crest.

2.3. Muscle power and quality

Leg extension power was measured using the Nottingham power rig (University of Nottingham Medical School, Model NG7 2UH, Nottingham, UK) and this procedure has been described previously [21]. To calculate an index of muscle quality (W/kg), leg extension power (W) was normalized for lower-body mineral-free lean mass (kg). The Nottingham power rig requires multiple joint actions including hip extension, knee extension and plantar flexion, and this measure of lean mass accounts for all musculature recruited for the testing movement. A ratio of muscle quality to whole-body mass (MQ/WB Mass) was calculated to further examine the relationship between ability to transfer body weight (muscle quality) and the weight to be moved (whole-body mass) [22].

2.4. Physical activity

Physical activity was measured via the Community Health Activities Model Program for Seniors (CHAMPS) questionnaire, which includes 41 questions regarding a variety of activities that individuals have completed regularly over the previous month [23]. The primary outcome measure utilized in the analysis was total caloric expenditure per week in moderate-intensity physical activities. This measure of physical activity has translational value as it is in accordance with the intensity of physical activity recommended for older adults in position statements by the American College of Sports Medicine [24]. The CHAMPS questionnaire has been shown to be a valid [25] and reliable [23] assessment of physical activity in older adults.

2.5. Lower-extremity physical function

The 6-min walk, 8-foot up-and-go, and 30-s chair stand tests were used to examine LEPF. Detailed methods of these functional assessments have been described elsewhere [21]. Similar to previous publications from our laboratory [21,22], a composite measure of LEPF was calculated by summing the Z-scores of each individual assessment (6-min walk, 8-foot up-and-go, 30-s chair stand) to provide a global index of LEPF.

2.6. Statistical analysis

All statistical analyses were conducted using SPSS for Windows version 22.0 (SPSS Inc., Chicago, IL). Histograms and distribution statistics (skewness and kurtosis) were examined to screen the data and it was determined that assumptions of normality were met as all variables had skewness and kurtosis values $< |2.0|$.