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Body composition and physical function in the Women's Health Initiative Observational Study

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ABSTRACT

Physical function is critical for mobility and quality of life. We hypothesized that higher total lean mass is associated with higher physical function, and body fat inversely associated, among postmenopausal women. Women's Health Initiative Observational Study participants at Pittsburgh, PA; Birmingham, AL; and Tucson-Phoenix, AZ (1993–1998) completed dual-energy X-ray absorptiometry scans and the Rand SF-36 questionnaire at baseline and 3 y (N = 4526). Associations between quartiles (Q1–4) of lean or fat mass and physical function were tested using linear regression, adjusted for demographics, lifestyle factors, medical history, and scanner serial number. At baseline, participants had a mean ± SD age of 63.4 ± 7.4 y and BMI of 27.4 ± 5.8 kg/m^2. Higher percent lean mass was positively associated with physical function at baseline (Q4, 83.6 ± 0.6 versus Q1, 74.6 ± 0.7; $p < 0.001$), while fat mass (kg and %) was inversely associated (e.g., Q4, 73.7 ± 0.7 versus Q1, 84.2 ± 0.7 kg; $p_{trend} < 0.001$). Physical function had declined across the cohort at 3 y; the highest relative lean mass quartile at baseline conferred a lesser decline in physical function than the lowest (Q4, −3.3 ± 0.6 versus Q1–7.0 ± 0.6; $p_{trend} < 0.001$), while the highest fat mass quartile (% and kg) conferred greater decline (ex. Kg Q4, −6.7 ± 0.7 versus Q1–2.8 ± 0.6; $p_{trend} < 0.001$). Increased fat mass (≥5%), but not lean mass, was associated with lower physical function at 3 y ($p < 0.001$). Adiposity, as well as lean mass, requires consideration in the prediction of physical function among postmenopausal women over time.

1. Introduction

The number of older adults (≥65 years) is rapidly increasing in the United States and expected to nearly double from 43.1 million in 2012 to 83.7 million by 2050 (Ortman et al., 2014). Maintaining physical function is important for independence and quality of life in older adults (Kuczmarski et al., 2010). Studies have found significant associations between body composition and physical function (Janssen et al., 2002; Newman et al., 2003; Sternfeld et al., 2002; Visser et al., 2000; Visser et al., 2002a), such that lower lean mass, termed sarcopenia, and higher fat mass are inversely related to physical performance measures. However, not all studies agree on the relationships between fat and lean mass and physical performance (Araujo et al., 2010; Visser et al., 2000).

Most studies of body composition and physical function have focused on adults over 65 years of age, which may inadvertently concentrate preventive efforts only to those in this age group. We found only one study among middle-aged adults, which included only males (Araujo et al., 2010). Since women begin with lower muscle mass (i.e. lean mass) than men and experience adverse changes in body composition with menopause (Kuczmarski et al., 2010; Sipila, 2003), it is important to investigate the association between body composition and physical function among postmenopausal women across a broader age range. Further, since these deleterious changes in body composition among postmenopausal women can be ameliorated through lifestyle interventions (Bea et al., 2010), it is important to understand the

Abbreviations: ASMI, appendicular skeletal muscle index; BMI, body mass index; Q, quartile

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relationship between body composition and physical function from menopause onward.

Here, we assess the relationship between body composition and physical function at baseline and at three years' follow-up among postmenopausal women both older and younger than 65 y. We hypothesized that higher lean mass at baseline would be associated with higher physical function, while higher fat mass would be associated with poorer physical function, at baseline and over three years follow-up.

2. Methods

2.1. Study population

The Women's Health Initiative (WHI) Study enrolled post-menopausal women aged 50–79 y at 40 clinical centers across the United States between 1993 and 1998. Women were recruited to any of four Clinical Trials or an Observational Study, as previously published (Hays et al., 2003; The Women's Health Initiative Study Group, 1998). Only women enrolled in the observational study who completed body composition evaluations at both baseline and year 3 were included in this analysis [Pittsburgh, PA; Birmingham, AL; and Tucson-Phoenix, AZ sites (N = 4526)] (Chen et al., 2008). Each institutional review board approved the protocol, and all participants provided written informed consent.

2.2. Physical function

Physical function was evaluated by the Medical Outcomes Study Scale (Rand SF-36 questionnaire) (Ware and Sherbourne, 1992). The physical function scale included 10 items measuring whether health limits physical function in moderate/vigorous activity (2 items); strength to lift, carry, stoop, bend, stair climb (4 items); ability to walk various distances without difficulty (3 items); and self-care (1 item). The scale was scored from 0 to 100. Higher scores indicate better function.

2.3. Body composition

Body mass index (BMI) was calculated as weight (kg) / height (m)^2. Height was measured on a wall-mounted stadiometer to the nearest 0.1 cm, and weight was measured on a balance-beam scale to the nearest 0.1 kg. Waist circumference was measured at the narrowest part of the torso over non-binding undergarments to the nearest 0.5 cm using an anthropometric tape. All anthropometric measures were conducted by study staff according to standard anthropometric measurement training (The Women's Health Initiative Study Group, 1998). Body composition, including whole body and regional bone mineral density, lean mass, and fat mass, was measured by dual energy X-ray absorptiometry (DXA; QDR2000, 2000+, or 4500W; Hologic Inc., Bedford, MA). The DXA centers used a rigorous WHI quality assurance program that has been previously published (Chen et al., 2005). DXA measures of lean mass were validated against magnetic resonance imaging for the assessment of skeletal muscle mass in a subset (Chen et al., 2007). Appendicular skeletal muscle index (ASMI) was computed from lean mass in the arms and legs and height measurements [ASMI = appendicular lean mass (kg) / height (m)^2].

2.4. Assessment of covariates

Self-report questionnaires at baseline were used to obtain information on demographics, medical history (e.g. hypertension, arthritis, disabled/currently unable to work), smoking status, and prior hormone therapy use. Diet was assessed by a validated food frequency questionnaire (FFQ) (Block et al., 1990). Protein intake (g/kg body weight) from the FFQ was adjusted based on equations developed in the WHI Nutritional Biomarkers Study (N = 544) which used doubly labeled water for energy and urinary nitrogen for protein, as well as BMI, age, race/ethnicity, and smoking status to better reflect true intake (Neuhouser et al., 2008). The Healthy Eating Index (HEI-2005) was computed from the FFQ (Guenther et al., 2008). Physical activity was assessed by a validated questionnaire, including frequency, intensity, and duration of activity (Eaglehouse et al., 2016; Johnson-Kozlow et al., 2007; Langer et al., 2003; Manson et al., 2002; Meyer et al., 2009; Nguyen et al., 2013). Energy expenditure (MET-hr/wk) was computed, as previously published (Ainsworth et al., 2000; Sims et al., 2012). Neighborhood socioeconomic status (NSES) was computed from 2000 census tract data (Dubowitz et al., 2012; Shih et al., 2011).

2.5. Statistical analyses

Baseline characteristics of participants were compared across quartiles of ASMI using analysis of variance (ANOVA) for continuous variables and chi-squared tests for categorical variables. Associations between each body composition variable at baseline (quartiles) and SF-36 physical function score at baseline (continuous) were estimated using linear regression. Potential confounders previously identified in the literature were included in the models: age, NSES, race/ethnicity, smoking status, physical activity, HEI-2005, protein intake, hormone therapy use, disability, history of hypertension and arthritis, and scanner serial number (Beasley et al., 2013; Fried et al., 2001). Further adjustment for medical history of emphysema, diabetes, or cancer did not significantly affect the models, so they were not included in the final models. Similar linear regression models, with further adjustment for baseline SF-36, were used to test associations between each body composition variable at baseline and change in SF-36 between baseline and year 3. Tests for trend were conducted by treating each body composition as a continuous variable. In additional models, change in each body composition measure between baseline and year 3 was categorized into three groups: decreased $\geq 5\%$, no change (change $< 5\%$ in either direction), and increased $\geq 5\%$. These categories were regressed on change in physical function scores over 3 years, with “no change” as the reference group. Potential interactions between each body composition measure and age ($<$ versus ≥ 65 y) on SF-36 were tested using likelihood ratio tests. Due to significant interactions between age and body composition on physical function change for several of the measures tested, these models were subsequently stratified by age. Similar tests for potential interactions with race/ethnicity in the groups with sufficient power (non-Hispanic white versus black) were also explored, but no significant results were found (data not shown). Likewise, no significant interactions with physical activity were detected (data not shown). All statistical analyses were conducted using Stata 15.1 (StataCorp, College Station, TX).

3. Results

Of the 4526 postmenopausal women included in the WHI Observational Study that completed body composition assessments twice, the women were on average 63.4 ± 7.4 years of age, primarily non-Hispanic white (81.5%), and non-smokers (92.7%), with a mean BMI of 27.4 ± 5.8 kg/m^2, waist circumference of 83.7 ± 13.3 cm, and physical activity of 12.9 ± 14.6 MET-hr/wk. Hormone therapy was currently used in 42.1% of participants. Physical function scores were wide ranging, encompassing the full scale of 0–100, and strongly left-skewed at baseline; the mean score was 80 ± 20 (median = 85). Total lean mass averaged 54.2 ± 7.2% of body weight, while total fat mass averaged 42.8 ± 7.4% of body weight overall. ASMI was relatively normally distributed; the mean was 5.5 ± 1.0 kg/m^2 (median 5.4 kg/m^2). ASMI ranged from 3.29 to 10.7 kg/m^2. Table 1 shows baseline characteristics of the WHI subset by quartiles of ASMI. Women in the highest quartile of ASMI were younger, with lower NSES and diet (HEI-2005) scores. Women in the highest quartile of ASMI were also more