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Associations of components of sarcopenic obesity with bone health and balance in older adults

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ABSTRACT

Objectives: To determine characteristics of sarcopenic obesity that are independently associated with bone health and balance in older adults.

Study design: Cross-sectional study of 168 community-dwelling older adults (mean age 67.7 ± 8.4 years; 55% women).

Main outcome measures: Appendicular lean mass (ALM), whole-body areal BMD (aBMD) and body fat percentage were assessed by dual-energy X-ray absorptiometry. Peripheral quantitative computed tomography assessed muscle density and cortical volumetric BMD (vBMD), area, thickness, and strength-strain index (SSI) at 66% tibial length. Hand grip strength (dynamometry) and balance path length (computerised posturography) were assessed. Obesity was defined as high body fat percentage.

Results: Greater lower-leg muscle density was associated with lower balance path length in men ($r = -0.36$; $P < .01$) and women ($r = -0.40$; $P = < .01$). Obese participants by body fat percentage did not differ to non-obese on bone indices, although a trend towards lower cortical vBMD was observed in obese compared with non-obese men (1041.4 ± 39.8 vs 1058.8 ± 36.1 mg/cm^3; $P = .051$). In multivariable models, ALM was positively associated with all bone parameters in obese women, and with whole-body aBMD, proximal tibial cortical area and SSI in non-obese women, and both non-obese and obese men (all $P < .05$). Lower-leg muscle density was also positively associated with cortical vBMD (B = 2.91; 95% CI 0.02, 5.80) and area (2.70; 0.06, 5.33) in obese women.

Conclusions: Amongst components of sarcopenic obesity, higher ALM is a consistent independent predictor of better bone health. Low muscle density may also compromise bone health and balance. Interventions which improve muscle mass and composition may lower fracture risk in sarcopenic obesity.

1. Introduction

Obese older adults with sarcopenia (inadequate skeletal muscle mass and function), may have increased risk for function declines (Roubenoff, 2004). We recently demonstrated that obesity combined with sarcopenia defined by the Foundation for the National Institutes of Health (FNIH) criteria (Studenski et al., 2014), is associated with increased fracture risk relative to obesity alone, but not an increased rate of falls (Scott et al., 2017). This suggests that increased fracture risk in sarcopenic obesity is related to poorer bone strength. Sarcopenic obese older adults have lower areal bone mineral density (aBMD) than obese alone older adults (Chung, Hwang, Shin, & Han, 2016; Huo et al., 2016; Scott et al., 2016). However, other measures of bone health, such as volumetric BMD (vBMD) and bone geometry, contribute to fracture risk independently of aBMD (Wong, 2016). Studies are required to determine whether sarcopenic obesity influences bone health in older adults, and which individual components are most important.

Age-related decreases in lower-limb muscle density, indicative of increases in fat infiltration between muscle fibres and within muscle cells (Miljkovic et al., 2015), are associated with functional decline and

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increased risk of falls (Frank et al., 2015; Frank-Wilson et al., 2016) and fractures (Lang et al., 2010) in older adults. Low muscle density may be more prevalent in sarcopenic obesity (Zamboni, Mazzali, Fantin, Rossi, & Di Francesco, 2008), potentially contributing to increased falls and fracture risk in this population. The aim of the present study was to determine the independent associations that components of sarcopenic obesity have with bone health and balance in community-dwelling older adults.

2. Materials and methods

2.1. Study design and participants

One-hundred and seventy-three community-dwelling adults aged ≥50 years residing in Melbourne, Australia who responded to advertisements at local hospitals, general practices, community groups, and sporting and recreation clubs, were recruited for this study. Participants were English speaking, capable of walking across a room unaided, and had no self-reported diagnosis of progressive neurological or psychotic disorders, severe arthritis (awaiting a joint replacement), or life expectancy < 12 months. The study was approved by the Melbourne Health Human Research Ethics Committee (HREC 2013.079 and HREC 2013.294) and was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). All participants provided written informed consent.

All testing was conducted at the Clinical Trials Unit at the Australian Institute for Musculoskeletal Science (AIMSS) between March 2014 and August 2016. Participants provided a fasted blood sample at the hospital pathology centre. Serum glucose, total and high-density lipoprotein (HDL) cholesterol, and triglycerides concentrations were analysed using the automated ADVIA 1650 Chemistry System (Siemens Healthcare Diagnostics Incorporation, Australia). The DiaSorin LIAISON (DiaSorin Inc, Stillwater, MN, USA) chemiluminescent immunoassay measured serum 25-hydroxyvitamin D (25OHD) concentrations.

A self-administered questionnaire including questions on employment status and chronic health conditions including cardiovascular disease (coronary heart disease and/or hypertension), diabetes and osteoporosis was completed. Self-rated health was also assessed by response to the question “Would you say that in general your health is:” with possible responses of: excellent; very good; good; fair; poor. Total minutes of weekly physical activity was assessed by the Active Australia Survey (Brown, Burton, Marshall, & Miller, 2008).

2.2. Anthropometrics, body composition and bone parameters

Weight (Seca 804 electronic scales, Seca, Hamburg, Germany) and height (Seca 222 wall-mounted stadiometer, Seca, Hamburg, Germany) were measured with footwear, headwear, and heavy items of clothing removed. Body mass index (BMI) was calculated as weight (kg)/height (m^2) and obesity was defined as BMI ≥30 kg/m^2.

A whole-body DXA (Hologic Discovery W, Hologic, Bedford MA, USA) determined whole-body (minus head) aBMD and total body fat, and regional lean and fat mass, including appendicular lean mass (ALM) and visceral fat area. Obesity according to body fat percentage was defined as total body fat percentage ≥30% for men or ≥40% for women (Scott, Daly, Sanders, & Ebeling, 2015). The DXA was calibrated daily using the manufacturer’s phantom. Short-term inter-individual coefficients of variation (CV) for whole-body BMD and ALM in our laboratory were 1.5 and 1.0%, respectively.

A single 2.5 mm transverse peripheral quantitative computed tomography (pQCT; Stratec XCT3000, Stratec Medizintechnik GmbH, Pforzheim, Germany) scan with a voxel size of 0.8 mm and scan speed of 20 mm/s was obtained at 66% of tibial length of the dominant leg, measured proximally beginning from the tibiotarsal joint. The dominant leg was preferentially selected for this assessment to allow comparability of muscle composition measures with strength assessments performed in the same limb (not included in the present study). Lower-leg muscle cross-sectional area (CSA; mm^2) and density (mg/cm^3) were determined using manufacturer’s algorithms and software (version 6.2). A threshold of 40 mg/cm^3 (mid-point density between fat and muscle tissue) separated fat and muscle. The short-term CV for muscle density in our hands was 1.0% (Scott, Trbojevic et al., 2015). The default threshold of 710 mg/cm^3 was used to separate cortical bone (Edwards et al., 2013). Proximal tibial cortical vBMD (mg/cm^3), area (mm^2) and thickness (average distance between periosteal and endosteal circumferences; mm) were recorded. Polar strength-strain index (SSI) was calculated with a threshold of 280 mg/cm^3 (Pollock et al., 2007). The device was calibrated daily using the manufacturer’s phantom. The CV for phantom density was 0.2% for the duration of the study.

2.3. Physical function

Dominant hand grip strength was assessed using a Jamar Plus Digital hydraulic hand grip dynamometer (Patterson Medical, Bolingbrook, IL, USA). Participants were seated with their elbow fully extended in front of them at shoulder height and gripped the dynamometer with maximal force for three seconds. The test was completed three times with a 30 s rest between trials and the mean value was recorded.

Balance path length (total distance travelled by the centre of pressure) was assessed during a bipedal standing balance task using a Nintendo Wii Balance Board (RVL-021; Nintendo, Kyoto, Japan) and custom software. The test measures movements in centre of pressure with acceptable reliability and validity compared to a laboratory-grade force platform (Clark et al., 2010; Huurnink, Fransz, Kingma, & van Dieën, 2013). Participants were required to stand with feet apart and eyes open for 30 s. Mean values from two trials with 30 s inter-trial rest periods were calculated. Higher path length values indicated poorer balance.

2.4. Statistical analyses

Continuous data were assessed for normality using Shapiro-Wilk tests and non-normally distributed variables were analysed using non-parametric tests. Sarcopenia was defined using the FNIH definition (ALM relative to BMI < 0.789 (men) or < 0.512 (women) and hand grip strength < 26 kg (men) or < 16 kg (women) (Studenski et al., 2014). Independent samples *t*-tests, Mann-Whitney *U* tests or Chi-square tests compared descriptive characteristics between men and women as appropriate. Sex-stratified Pearson correlations explored associations between components of sarcopenic obesity (ALM, hand grip strength, total body fat percentage and lower-leg muscle density), bone indices (whole-body aBMD, and proximal tibial cortical vBMD, area, thickness and SSI) and balance path length. Independent samples *t*-tests compared bone indices between obese and non-obese men and women according to both BMI and body fat percentage. Multivariable linear regression models adjusted for age and sex explored associations between sarcopenic obesity components and bone indices. These analyses were also adjusted for fasting blood glucose given that type 2 diabetes may be associated with both sarcopenic obesity and poor bone health. In order to explore independent associations of sarcopenic obesity components with bone health, each component was included in all models. Plots of residuals against the predictor variable were used to test assumptions of normality of residuals and homoscedasticity, and Variance Inflation Factors were examined to confirm the absence of multicollinearity between independent variables included in these models. P-values < 0.05 or 95% confidence intervals (CI) not including the null point were considered statistically significant. All analyses were performed in SPSS Statistics 22 (IBM, USA).