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SHORT COMMUNICATION

Abdominal adiposity and low physical activity are independently and inversely associated with bone mineral density

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Summary
Background and Methods: Obesity is a highly heterogeneous condition, and the link between adiposity distribution profiles and skeletal health is not well understood. This study examined the association between adiposity and bone mineral density (BMD) in a large cohort (5268 individuals) of US adults aged 20—85 years.
Results: Body mass index (BMI) and moderate-to-vigorous physical activity were positively associated with BMD. Conversely, abdominal adiposity was negatively associated with BMD, even after adjusting for age, race, BMI, and objectively-measured physical activity.
Conclusions: These findings highlight the negative influence of abdominal adiposity on BMD and contradict the notion that excess fat mass is protective for bone health.

Introduction

Obesity is a heterogeneous condition that must be considered in the broader biological context in which it is contained. Accumulating evidence indicates that excess storage of adipose tissue in non-subcutaneous depots (e.g., visceral, muscle, liver, etc.) is strongly associated with chronic diseases [1—6], and may mediate the association between high body mass indexes (BMIs) and adverse cardiometabolic outcomes [7]. At present, the link between adiposity distribution profiles and skeletal health is not well understood. For example, a

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recent study using the National Health and Nutrition Examination Survey (NHANES) dataset suggested a protective association between obesity (as determined using BMI) and osteoporosis risk [8]. The authors concluded that a 10-unit increase in BMI, which could move an individual from normal weight to the obese category, would result in moving an individual from an osteoporotic to a normal bone mineral density (BMD) category. This finding, though interesting, is contradictory to recent evidence indicating that excess adiposity negatively affects bone and muscle health [9–11]. Indeed, we recently showed that excess visceral adiposity is negatively associated with lumbar spine BMD and quality of the psoas muscle [12]. A possible explanation for these contradictory findings is that BMI does not provide a complete picture of adiposity distributions, and moreover, cannot discriminate between lean tissue and fat mass. Thus, it is likely that the direction of association between adiposity and BMD may differ based on regional differences in adiposity storage, as well the adipose tissue indicator/measure used in the analysis (i.e., BMI vs. direct measure of fat). Further, it is likely that this association may vary by age, sex, race and physical activity levels. Therefore, the purposes of this study were to examine the associations between abdominal adiposity and BMD across a large, representative sample of the US population, as well as to determine the mediating influences of age, sex, and objectively measured physical activity.

Methods

Study design and sample

Data for this study were obtained from the NHANES 2003/2004 and 2005/2006 surveys. Of the 9515 participants of the NHANES 2003–2006 who were 20 years and older, 5268 had valid body composition and bone mineral density data from dual-energy X-ray absorptiometry (DXA), and 4-days of objectively measured activity.

Demographic and anthropometrics factors

Socio-demographic characteristics were all assessed by self-report during the in-home interview. Age was used as a continuous variable. Race/ethnicity was categorised as: (1) non-Hispanic white, (2) non-Hispanic black, and (3) Mexican American or other Hispanic.

BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Standard categories were applied to determine if each participant was normal weight (18.5–24.9), overweight (25–29.9), or obese (≥30). Individuals with BMI <18.5 kg/m^2 were excluded, due to the known association between underweight status and musculoskeletal frailty [13].

Body composition and abdominal adiposity

The NHANES DXA scans were administered using a Hologic QDR-4500A fan-beam densitometer with Hologic software (Hologic Corp., Bedford, MA). Total lean mass, excluding bone mass and total fat mass, and total percent body fat (%BF) were reported. In addition, the Hologic APEX software computed adipose tissue within the abdominal area (area around the waist between the mid-point of the lumbar spine and the top of the pelvis) of a total body DXA scan. Abdominal adipose tissue thus represents the combined total of subcutaneous and visceral adipose tissue, and is presented in total grams.

Bone mineral density

Total body BMD and BMD of the lumbar (L1–L4) spine were measured from whole-body DXA scans. The scans were analysed using the Hologic software, APEX v3.0, which has been shown to have good precision [14]. The details of the DXA data-acquisition protocol, quality control analysis, and the multiple imputation procedures are available in the Body Composition Procedures Manual on the NHANES website, and through the National Center for Health Statistics: http://www.cdc.gov/nchs/nhanes/dxx/dxa.htm.

Objective activity assessment

Subjects' habitual physical activity and sedentary behaviour (counts per minute (cpm)) were assessed for 7 days with an accelerometer (Actigraph 7164; Actigraph, LLC, Pensacola, FL) worn on their right hip during waking hours. Four days of monitoring with at least 10 h per day were necessary for inclusion [15]. Accelerometer counts were used to classify all worn time as time spent in sedentary behaviour (<100 cpm), light-intensity activity (100–759 cpm), lifestyle moderate activity (760–2019 cpm), and moderate-to-vigorous physical activity (MVPA) (≥2020 cpm) as previously described [16].

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