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Body composition and its association with cardiometabolic risk factors in the elderly: A focus on sarcopenic obesity

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ABSTRACT

Important changes in body composition with aging are a progressive loss of muscle mass and increase of fat mass. Despite their enormous clinical importance, body composition changes such as sarcopenic obesity in the elderly are under-recognized. This study aimed to examine the relationship of body composition with a wide variety of cardiometabolic risk factors among 2943 subjects (1250 men and 1693 women) aged 60 years or older from Korean National Health Examination and Nutrition Survey (KNHANES). Sarcopenia was defined as an appendicular skeletal muscle mass (ASM) divided by weight (%) of <1 SD below the sex-specific mean for young adults. Obesity was defined as a body mass index (BMI) ≥25 kg/m^2. Body composition was categorized into four non-overlapping groups: the sarcopenic obese, sarcopenic nonobese, nonsarcopenic obese, and nonsarcopenic nonobese groups. A wide variety of cardiometabolic risk factors, including blood pressure (BP), glucose tolerance indices, lipid profiles, inflammatory markers, and vitamin D level, were compared according to body composition group. The prevalence of sarcopenic obesity was 18.4% in men and 25.8% in women. In both sexes, the prevalence of vitamin D deficiency and metabolic syndrome was highly prevalent in the sarcopenic obese group. Serum insulin level, homeostasis model assessment of insulin resistance (HOMA-IR), triglyceride levels, and ferritin levels were the highest in the sarcopenic obese group in both men and women, whereas HDL-cholesterol and 25-hydroxyvitamin D (25(OH)D) levels were the lowest in the sarcopenic obese group. The sarcopenic obese group was more closely associated with insulin resistance, metabolic syndrome, and cardiovascular disease (CVD) risk factors than any other group in this elderly population.

1. Introduction

The two greatest public health concerns in developed countries are the aging of the population and the obesity epidemic (Mokdad et al., 2001). Each of these trends has important effects on body composition, functional disability, and mortality. Aging causes a progressive loss of muscle mass and strength, called sarcopenia, which is derived from the Greek for 'poverty of flesh' (Rosenberg, 1989). Another important change in body composition with aging is the increase of fat mass and visceral fat (Riechman, Schoen, Weissfeld, Thaete, & Kriska, 2002), which increases susceptibility to metabolic syndrome and CVD (Ryan & Necklas, 1999). Therefore, the coexistence of sarcopenia and obesity in the elderly may synergistically maximize their effects on metabolic and CVD risk (Stenholm et al., 2008; Zamboni, Mazzali, Fantin, Rossi, & Di Francesco, 2008). These age-related body composition changes, with the decrease of skeletal muscle mass and the increase of body fat mass, may occur even in an individual elderly person of stable body weight, which has recently been defined as sarcopenic obesity (Lim et al., 2010; Zamboni et al., 2008). Sarcopenic obesity may be particularly deleterious because of its possible association with a proinflammatory state. Adiopocytes actively secrete leptin and proinflammatory cytokines (Mohamed-Ali, Pinkney, & Coppack, 1998; Reuben, Judd-Hamilton, Harris, & Seeman, 2003), both of which stimulate muscle catabolism (Bullo-Bonet, Garcia-Lorda, Lopez-Soriano, Argiles, & Salas-Salvado, 1999; Hotamisligil, 1999; Roubenoff et al., 1997) and activate a vicious cycle leading to accelerated sarcopenia, additional weight gain largely in the form of fat.

The Korean population is rapidly aging and becoming an aged society as are other developed countries. Approximately 10.3% of the Korean population was aged 65 and older in 2008, and the percentage is expected to rapidly rise to 20.3% in 2027 and 34.4% in 2050 (Korea National Statistical Office, 2005). Despite their enormous clinical importance, body composition changes such as sarcopenic obesity in the elderly are often under-recognized. Moreover, there is a paucity of data that measure the effects of body composition on insulin resistance and CVD risk factors, and

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those data that do exist are often with conflicting results. We examined the relationship between body composition and a wide variety of cardiometabolic risk factors among a representative elderly population, aged 60 years or older, who participated in the KNHANES.

2. Patients and methods

2.1. Study population

This study was based on data obtained from the 2008 to 2009 KNHANES, a cross-sectional and nationally representative survey conducted by the Korean Ministry of Health and Welfare. The survey target population was non-institutionalized civilians over one year of age in Korea. The sampling units were households selected through a stratified, multistage, probability-sampling design based on geographic area, sex, and age group using household registries. Participants completed four parts of a questionnaire that consisted of a health interview survey, health behavior survey, health examination survey, and nutrition survey. In this study, 12,528 subjects from 4000 households and 12,722 subjects from 4000 households were included in the 2008 and 2009 surveys, respectively. The response rates were 77.8% and 82.8% in 2008 and 2009, respectively. Blood tests were performed on 19,486 (9308 in 2008, 10,078 in 2009) individuals aged ≥10 years. After excluding 15,806 (7636 in 2008, 8170 in 2009) individuals younger than 60 years of age, 4471 subjects (1856 men, 2615 women) were used for the current study. Subjects who had not fasted for at least 12 h prior to blood sampling, subjects with triglyceride level exceeding 400 mg/dL, and subjects with any missing data for the metabolic syndrome component of the survey were excluded ($n = 1629$). A whole body dual energy X-ray absorptiometry (DXA) scan was performed for each subject to measure total and regional lean mass (kg), total body fat (kg), and total body fat percentage (%) using fan-beam technology (Lunar Corp., Madison, WI, USA). Those who had not performed DXA were also excluded ($n = 1310$). After these exclusions, 2943 subjects (1250 men, 1693 women) were included in our final analysis. This study was approved by the Institutional Review Board of Yonsei University College of Medicine.

2.2. Data collection

At the time of the 2008 and 2009 KNHANES, citizens were informed than they had been randomly selected as a household to voluntarily participate in a nationally representative survey conducted by the Korean Ministry of Health and Welfare, and that they had the right to refuse to participate in a accordance with the National Health Enhancement Act supported by the National Statistics Law of Korea. The participants gave written informed consent to participation in the study. The Korea Centers for Disease Control and Prevention also obtained written informed consent to use blood samples from the participants for further analysis. The health examination, which was performed in 2008 and 2009, included a medical history, physical examination, a questionnarie about health-related behaviors, anthropometric and biochemical measurements, and DXA. Physical examinations were performed by trained medical staff following standardized procedures. Participants were asked about lifestyle behaviors, including cigarette smoking and alcohol consumption.

Smoking status was categorized as either nonsmoker or current smoker. Based on how often participants consumed any type of alcohol, alcohol consumption was considered two drinks or more per week. All subjects were instructed to record their daily engagement in moderate or vigorous exercise during the previous 7-day period. Regular exercise was defined as follows: subjects who were engaged in moderate intensity exercise ≥5 times/week or in vigorous intensity exercise ≥3 times/week. If a subject was being treated for any disease, they were asked for data on the diagnosis and a list of medications being taken. Completed questionnaries were reviewed by trained staff and entered into a database. Body weight (Wt) and height were measured with the subject wearing light indoor clothing without shoes to the nearest 0.1 kg and 0.1 cm, respectively. Waist circumference (WC) was measured at the narrowest point between the lower border of the rib cage and the iliac crest. BMI was calculated as the ratio of weight (kg)/height squared (m^2). BP was measured in the right arm using a standard mercury sphygmomanometer (Baumanometer, USA). Two systolic and diastolic blood pressure (DBP) readings were recorded at 5-min intervals and averaged for analysis. After a 12-h overnight fast, blood samples were obtained from an antecubital vein of the study subjects. Fasting plasma glucose, total cholesterol, triglyceride, and high-density lipoprotein (HDL)-cholesterol levels, and a liver function and kidney function test were performed using a Hitachi 700–110 chemistry analyzer (Hitachi, Tokyo, Japan). Fasting insulin levels were measured by immunoradiometric assay (Biosource, Belgium) using a γ-counter (1470 Wizard; PerikinElmer, Turku, Finland). White blood cell (WBC) counts were quantified by an automated blood cell counter (ADIVA 120, Bayer, NY, USA). Serum ferritin levels were measured by immunoradiometric assay (DiaSorin Inc., Stillwater, MN) using a γ-counter (1470 Wizard; PerikinElmer, Turku, Finland). Serum 25(OH)D concentrations were measured by radioimmunoassay (DiaSorin Inc., Stillwater, MN) using a γ-counter (1470 Wizard; PerkinElmer, Turku, Finland). Plasma low-density lipoprotein (LDL)-cholesterol values were estimated using the following formula: total cholesterol (mg/dL) – HDL-cholesterol (mg/dL) – triglycerides (mg/dL)/5 (Friedewald, Levy, & Fredrickson, 1972). The homeostasis model assessment of insulin resistance (HOMA-IR) was calculated using the following formula: fasting plasma glucose (mg/dL) × fast-fasting insulin (μIU/mL)/22.5 (Matthews et al., 1985). Kidney function was estimated using glomerular filtration rate (GFR), which was calculated with the simplified Modification of Diet in Renal Disease (MDRD). The study equation was: $GFR = 186.3 \times (\text{serum creatinine (mg/dL)})^{-1.154} \times \text{age}^{-0.203} \times 0.742$ for a female subject (Levey et al., 1999, 2003).

2.3. Definition of metabolic syndrome

Definitions for metabolic syndrome and its components were based on the National Cholesterol Education Program Adult Treatment Panel III guidelines, and we used ethnicity-specific values for WC based on data from the World Health Organization (WHO) and the Korean Society for the Study of Obesity (KSSO) (Lee et al., 2007). Metabolic syndrome was thus defined by the presence of three or more of the following risk factors: central obesity (WC ≥ 90 cm for men and ≥80 cm for women); systolic blood pressure (SBP) ≥130 mmHg and diastolic blood pressure (DBP) ≥85 mmHg; fasting plasma glucose levels ≥100 mg/dL; triglyceride levels ≥150 mg/dL; and low HDL-cholesterol levels (<40 mg/dL for men and <50 mg/dL for women). Subjects who reported taking antihypertensive or antidiabetes medications were considered to have elevated BP or high fasting plasma glucose levels.

2.4. Definition of sarcopenia and obesity

ASM was measured by DXA. ASM (kg) was defined as the sum of lean soft tissue masses for the arms and legs, after the method of Heymsfield et al. (1990). We used ASM as a percentage of whole Wt, as modified from studies by Jassen, Heymsfield, and Ross (2002) and Lim et al. (2010). Sarcopenia was defined as an ASM divided by Wt (ASM/Wt) that was less than 1 SD below the mean of