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Relationship between water intake and skeletal muscle mass in elderly Koreans: A nationwide population-based study

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ABSTRACT

Objectives: The purposes of this study were to evaluate the correlation between sarcopenia and water intake and investigate lack of daily water intake in the presence of sarcopenia in an elderly population.
Methods: Data from 3656 participants (1582 men and 2074 women) were analyzed using the Korea National Health and Nutrition Examination Survey. Sarcopenia was defined in accordance with the criteria of the Asia Working Group for Sarcopenia. Water intake was assessed using the dietary water adequacy ratio and was calculated by dividing the daily water intake from fluid by the recommended daily amount of 1000 mL in men and 900 mL in women.
Results: Water intake from food (g/d and cup/d) and dietary water adequacy ratio (mL) were significantly lower in the sarcopenia group (757.8 g, 890.1 g, and 0.74 mL in men; 511.9 g, 757.8 g, and 0.70 mL in women, respectively) than in the non-sarcopenia group (878.4 g, 1015.1 g, and 0.81 mL in men; 581.3 g, 790.5 g, 0.74 mL in women, respectively). In elderly men, the odds ratio of sarcopenia in the lowest quartile increased to 1.47 (range, 1.13–1.91) in Model 2 compared with that in the highest quartile. In elderly women, the odds ratio of sarcopenia in the lowest quartile increased to 1.50 (range, 1.08–2.08) in Model 2 compared with that in the highest quartile.
Conclusions: The prevalence of sarcopenia in the elderly population was related to inadequate dietary water intake after adjusting for covariates. Adequate water intake in the elderly should be recommended to prevent dehydration-related complications, including sarcopenia.

Introduction

Water accounts for approximately 60% to 70% of human body weight and is essential for the digestion, absorption, transfer, excretion, and circulation of biomolecules as well as the regulation of the body temperature [1]. Skeletal muscle retains a large volume of water, which accounts for up to 75% of muscle mass [2]. However, water intake can decline in elderly people due to their decreased thirst sensation that is caused by the dysfunction of the thirst-regulating mechanism [3]. Decreased water intake in the elderly can result in lower urine production and decreased ability of the kidneys, which may lead to various chronic diseases [3,4].

The rapid increase in the elderly population has boosted interest in a variety of chronic diseases [5] including age-related decrease in the masses and function of skeletal muscles (i.e., sarcopenia). A strong correlation has been reported between sarcopenia and increased mortality and other chronic diseases among patients [6].

Various risk factors including deficiencies of protein and vitamin D and chronic inflammation have been reported as the causes of sarcopenia but there has been little research on water content, which is one of the most important factors in the generation with skeletal muscle conditions [7].

The purposes of this study were to evaluate the correlation between sarcopenia and water intake and to investigate the lack

Conflicts of interest: None.

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of daily water intake by the presence of sarcopenia in the elderly population.

Methods

Ethics statement

Data from the 2008 to 2011 Korean National Health and Nutrition Examination Survey (KNHANES) were reviewed and approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (Approval No. 2008–04 EXP-01-C, 2009–01 CON-03-C, 2010–02 CON-21-C, and 2011–02 CON-06-C). Informed consent was obtained from all participants when the 2008, 2009, 2010, and 2011 KNHANES were conducted.

Participants

KNHANES was a nationwide, representative, cross-sectional survey of the Korean population with a clustered, multistage, stratified, and rolling sampling design. KNHANES consisted of a health interview, health examination, and dietary survey. The survey data were collected from household interviews and direct standardized physical examinations that were conducted in specially equipped mobile examination centers. The data were collected from 37 753 participants in 2008 (n = 9744), 2009 (n = 10 533), 2010 (n = 8958), and 2011 (n = 8518). Participants were excluded if they were age <65 y, if data were not available to evaluate skeletal muscle mass or dietary intake, or if the participants consumed at least three cups of coffee per day. After these exclusions, data from 3656 participants (1582 men; 2074 women) remained and were analyzed (Fig. 1).

Adequate water intake

Water intake in the data was based on the measurement of 1 cup (200 mL). According to the Dietary Reference Intakes for Koreans, adequate water intake under standard conditions is 1000 mL daily for elderly men and 900 mL daily for elderly women [8].

Dietary water adequacy ratio

Water intake was assessed using the dietary water adequacy ratio (DWAR) and calculated by dividing the daily water intake from fluid by the recommended daily amount of 1000 mL in men and 900 mL in women in accordance with the 2015 nutrient intake standard for Koreans [8]. The maximum value of DWAR was considered as 1.0 to prevent the increase of the index due to exceeding the recommended dietary intake.

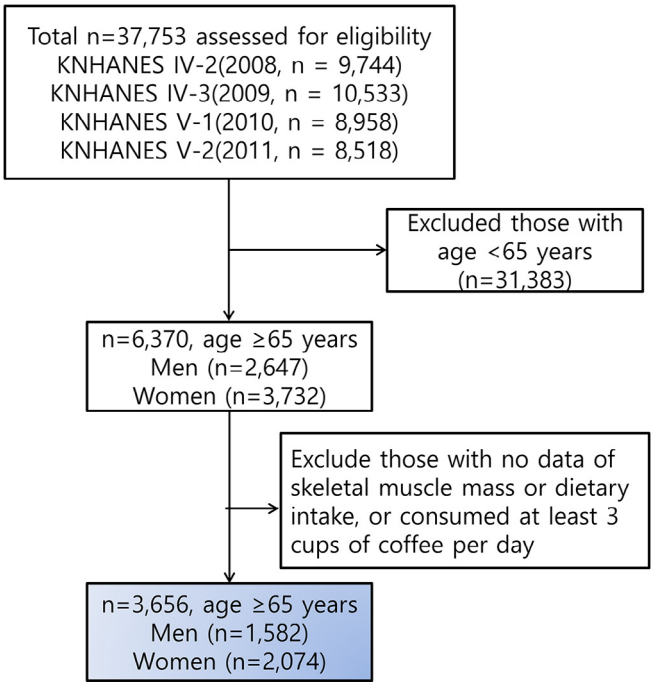

Fig. 1. Selection process of study subjects, KNHANES IV and V (2008–2011).

Health examination survey

A health questionnaire was used to obtain information on age, sex, socioeconomic status, education status, smoking status (current, former, or never), alcohol intake, moderate physical activity, and walking activity (yes or no). Moderate physical activity was defined as ≥5 d of moderately intense activity for at least 30 min/d. Walking physical activity was defined as ≥5 d of walking for at least 30 min/d. Body weight and height were measured in light clothing with no shoes and body mass index was calculated as weight (kg) divided by height squared (m^2). Information with regard to comorbidities including diabetes, chronic obstructive pulmonary disease, chronic renal failure, and malignancy as potential confounding factors were examined using the health interview survey.

Dietary intake measurement

Dietary intake was assessed by trained staff using a complete 24-h recall method. The daily intake of energy and protein was calculated by referencing nutrient concentrations in foods in accordance with the Korean Food Composition Table [8].

Biochemical analyses

Blood and urine samples were collected in the morning after fasting for at least 8 h. Collected samples were immediately refrigerated and transported at cold temperatures (4–8°C) to the central laboratory of Neodin Medical Institute (Seoul, Korea) within 24 h. The transported samples were separated into small aliquots and stored at −70°C.

Serum 25-hydroxyvitamin D, parathyroid hormone, and alkaline phosphatase levels were measured using a 1470 Wizard gamma counter (Perkin Elmer, Turku, Finland), Automatic Analyzer 7600 (Hitachi, Ltd., Tokyo, Japan), and LIAISON (DiaSorin, Stillwater, MN) with radioimmunoassay (25-hydroxyvitamin D ^{125} I RIA Kit; DiaSorin), enzymatic (Pureauto S ALP; Sekisui Medical Co., Ltd, Tokyo, Japan), and chemiluminescence immunoassay (N-tact PTH Assay kit; DiaSorin), respectively.

Measurements of appendicular skeletal muscle mass

Body composition was measured by whole-body dual x-ray absorptiometry using a QDR 4500 A apparatus (Hologic, Inc., Waltham, MA). Bone mineral content, fat mass, and lean soft-tissue mass were measured separately for each part of the body including the arms and legs. The lean soft-tissue masses of the arms and legs were nearly equal to the skeletal muscle mass. Absolute muscle mass correlates with height so the skeletal muscle mass index was calculated as: Lean mass [kg]/height $[m]^2$, which was directly analogous to body mass index (kg/m^2).

Arm skeletal muscle mass index was defined as arm lean mass [kg]/height $[m]^2$. Leg skeletal muscle mass index was defined as leg lean mass [kg]/height $[m]^2$. Appendicular skeletal muscle mass index (SMI) was defined as the sum of the arm and leg SMIs. Sarcopenia was defined in accordance with the criteria of the Asia Working Group for Sarcopenia (SMI <5.4 kg/m^2 in women and <7.0 kg/m^2 in men) [9].

Statistical analyses

Complex sample analyses were used to correct for the distributions of the cluster samples with regard to the primary sampling unit, covariance, and significance to correspond with those of the general Korean population. All analyses were conducted with the sample weights of KNHANES.

DWAR was categorized separately as follows: Quartile (Q)1 < 0.33; 0.33 ≤ Q2 < 0.66; and 0.66 ≤ Q3 ≤ 1.0 in both sexes. Low water intake was assumed to be <1000 mL/d for men and <900 mL/d for women.

To compare means and proportions between each group, Student t and χ^2 tests were performed. Variables with a P value < 0.05 were included in the multivariate model. A multiple logistic regression analysis was conducted to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for the association between adequate water intake and the presence of sarcopenia after adjustment of the demographic variables that served as covariates. A three-step logistic regression analysis model was used to examine the correlation between adequate water intake with sarcopenia after gradually adjusting for confounding factors that affect water intake.

All statistical tests were two-tailed and statistical significance was defined as $P < 0.05$. The statistical calculation was performed using SPSS Statistics, Version 22 (SPSS, Chicago, IL).