Maturitas 82 (2015) 360–364

Contents lists available at ScienceDirect

Maturitas

journal homepage: www.elsevier.com/locate/maturitas

Tooth loss and bone mineral density in postmenopausal South Korean women: The 2008–2010 Korea National Health and Nutrition Examination Survey

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ARTICLE INFO

Article history:
Received 11 June 2015
Accepted 22 July 2015

Keywords:
Bone mineral density
Osteoporosis
Tooth loss
Postmenopausal women
Korea National Health and Nutrition Examination Survey

ABSTRACT

Purpose: The current study aimed to investigate the association between the number of remaining teeth and bone mineral density (BMD) using data from the Korean National Health and Nutrition Examination Survey (KNHANES) 2008–2010.
Methods: This study enrolled 7315 Korean subjects (3364 men over 50 years of age and 3951 postmenopausal women). BMD was measured using dual-energy X-ray absorptiometry at three sites: the total femur (TF), femur neck (FN), and lumbar spine (LS). The number of teeth present was categorized into four groups (≤10, 11–20, 21–25, and ≥26 teeth).
Results: More remaining teeth were significantly associated with a higher BMD at the TF, FN, and LS in postmenopausal women after adjusting for all the covariates, but not in elderly men. In both sexes, subjects with a normal BMD tended to have more remaining teeth than those who were diagnosed with osteopenia and osteoporosis. A lower prevalence of osteoporosis was also significantly associated with more remaining teeth (number of teeth ≥26) in postmenopausal women. This trend was statistically significant in osteoporosis at the FN (p for trend = 0.019).
Conclusion: The number of remaining teeth was associated with osteoporosis, especially at the FN, in postmenopausal women.

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1. Introduction

Tooth loss and osteoporosis are major public health problems in the elderly [1,2]. Poor dentition status is associated with the deterioration of systemic health via dietary intake alterations [3]. Common causes of tooth loss are dental caries, periodontal disease, trauma, eruption problems, and economic factors [4]. Osteoporosis, which is characterized by the deterioration of the bony microarchitecture and low bone mass, is a systemic skeletal disease. It leads to increased susceptibility to fractures, which are related to a high morbidity and increased medical costs [4,5]. An advanced age and being a postmenopausal woman are well known risk factors for osteoporosis. At the same time, women also lose more teeth after menopause [4].

Since the first report by Daniell [6], various studies have investigated the relationship between tooth loss and osteoporosis, with inconsistent results. Although some studies did not find a definite association between tooth loss and osteoporosis or bone mineral density (BMD) [7–9], other researchers have identified a correlation between osteoporosis and tooth loss [1,2,4,10–15]. Thus, the association between tooth loss and osteoporosis is still unclear and should be further investigated.

Most previous studies have examined the association between tooth loss and osteoporosis. However, the aforementioned studies were performed on a relatively small number of subjects, and they focused only on postmenopausal women without including elderly men. Thus, this study intended to examine the association between the number of remaining teeth and BMD using representative data of Korean adults from the Korean National Health and Nutrition Examination Survey (KNHANES) conducted from 2008 to 2010.

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http://dx.doi.org/10.1016/j.maturitas.2015.07.016
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2. Materials and methods

2.1. Survey overview

Data from the 2008–2010 KNHANES were used in this study. The KNHANES was first performed in 1998 by the Division of Chronic Disease Surveillance at the Korean Center for Disease Control and Prevention as a nationwide survey. The KNHANES evaluates nutrition and health at the national level, and it is composed of a physical examination, health interview, and nutritional survey [16]. To obtain a representative sample of the non-institutionalized civilians from all geographic regions in the country, all subjects were stratified into multiple stages, selected using a cluster sampling design, and prorated by age from the 2005 National Census Registry. Face-to-face interviews were performed by trained interviewers.

2.2. Subjects

The KNHANES included 27,858 subjects aged ≥19 years. We only selected men over the age of 50 and postmenopausal women. Thus, 20,111 subjects were excluded. Second, 282 subjects who had insufficient data were also excluded from the study. Third, we excluded those who had been treated for osteoporosis and periodontitis. Finally, 7315 subjects (3364 men and 3951 women) were included in this study. The protocol of the current study was approved by the institutional review board of Korean Center for Disease Control and Prevention (2008-04EXP-01-C, 2009-01CON-03-2C, and 2010-02CON-21-C), and this study was conducted according to the Ethical Principles for Medical Research Involving Human Subjects, as defined by the Declaration of Helsinki. Written informed consent was obtained from all participating subjects before the study began.

2.2.1. Anthropometric measurements

Participants wore only light clothes without shoes, and a trained examiner measured their height (cm) and weight (kg) to the nearest 0.1 cm and 0.1 kg, respectively. The body mass index (BMI) was calculated by dividing the weight (kg) by the height squared (m^2).

2.2.2. Biochemical measurements

After fasting for more than 8 h, serum blood samples were collected from participants. Alkaline phosphatase (ALP) levels were measured enzymatically using the Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan); the serum 25(OH)D was analyzed by performing a radioimmunoassay (RIA) using a 25-hydroxyvitamin D 125I RIA kit (DiaSorin, Stillwater, MN, USA) and a gamma counter (1470 Wizard; PerkinElmer, Turku, Finland) after transporting the samples to the Central Testing Institute in Seoul, South Korea.

2.2.3. Socio-demographics/general and oral health behaviors

Participants were surveyed to gather socio-demographic variables, and they completed a self-administered questionnaire regarding sex, age, education level, and family income. The education level of participants was categorized according to whether they had graduated from high school. Their household income was adjusted for the number of family members and divided into quartiles.

General health behaviors were reported by the participants. Heavy drinkers were defined as those who drank ≥30 g/day. Current smokers were those subjects who currently smoked and had smoked at least 100 cigarettes in their entire lives. Physical activity was defined using the International Physical Activity Questionnaire [17]. The regular exercise group was established as those who exercised more than 30 min/session or those who exercised more than 3 times/week at an intense level for more than 20 min/session.

2.2.4. Remaining teeth

Participants were asked whether they had lost their natural teeth, and the number of teeth present was counted.

2.2.5. BMD measurement

Whole-body, dual-energy X-ray absorptiometry (DXA) was performed with a QDR Discovery (formerly known as the QDR 4500A) fan beam densitometer (Hologic, Inc., Bedford, MA, USA) following the procedures recommended by the manufacturer. All subjects wore light clothes and removed all jewellery and other items that could interfere with the BMD measurement. BMD was measured at the total femur (TF), femur neck (FN), and lumbar spine (LS). The DXA results were analyzed using the standard techniques of the Korean Society of Osteoporosis and Hologic Discovery software (version 13.1).

2.2.6. Osteopenia and osteoporosis

The diagnosis of osteoporosis and osteopenia was based on the measurement of BMD using the DXA results for TF, FN, and LS according to the WHO diagnostic classification [18]. Osteopenia was defined as a BMD of 1.0 standard deviation (SD) below the peak bone mass of a young, healthy, race- and sex-matched reference population. Osteoporosis was characterized by a BMD of 2.5 SD as follows: (1) normal bone mass: $-1.0 < T$-score, (2) osteopenia: $-2.5 < T$-score ≤ -1.0, and (3) osteoporosis: T-score ≤ -2.5 [19].

2.3. Statistical analyses

Data were presented as percentages for categorical variables or as the mean ± standard error (SE) for continuous variables. Student's t-test was used for continuous variables, and the Chi-square test was employed for categorical variables to analyze the characteristics of the subjects. A multi-variable linear regression model was applied to analyze the relationship between the number of remaining teeth and BMD for every increment of 0.1 g/cm^2. Model 1 was adjusted for age and BMI, and model 2 was adjusted for the covariates of model 1 and alcohol intake, cigarette smoking, regular exercise, ALP, 25(OH)D, and daily calorie and calcium intake. Analysis of covariance was used to examine the prevalence of normal BMD, osteopenia, and osteoporosis in the subjects according to the number of remaining teeth categorized into four categories (≤10, 11–20, 21–25, and ≥26). There were two multivariable adjusted logistic regression analyses were applied to examine the odds ratios (ORs) and 95% confidence intervals (CI) of the prevalence of osteoporosis according to the number of remaining teeth. Model 1 was adjusted for age and BMI. Model 2 was adjusted for the covariates of model 1 and alcohol intake, cigarette smoking, regular exercise, ALP, 25(OH)D, and daily calorie and calcium intake.

The SAS software package version 9.2 for Windows (SAS Institute Inc., Cary, NC, USA) was used to account for the complex sampling design and to provide approximations of the entire Korean population. All statistical tests were two-tailed, and a $p < 0.05$ was considered statistically significant.

3. Results

Table 1 shows the general characteristics of the study participants by gender. The mean age was 61.3 ± 0.2 years for men and 62.8 ± 0.2 years for women. Men showed a higher BMD than women at the TF (0.930 ± 0.003 vs. 0.774 ± 0.002), FN (0.754 ± 0.003 vs. 0.624 ± 0.002), and LS (0.943 ± 0.003 vs. 0.808 ± 0.003) (all $p < 0.001$). Serum vitamin D, daily calorie and calcium intake, proportions of current smoking status, heavy alcohol drinking, regular exercise, and education level were higher in men than they were for women (all $p < 0.001$). Women showed a higher BMI, serum ALP levels, and proportion of low income than

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