High prevalence of vitamin D deficiency among middle-aged and elderly individuals in northwestern China: Its relationship to osteoporosis and lifestyle factors

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Abstract

Purpose: Vitamin D deficiency has reached epidemic proportions; this deficiency has been associated with osteoporosis and certain lifestyle factors in adults. This relationship is not well documented among the Lanzhou population in northwest China. This study sought to determine the prevalence of vitamin D deficiency and its risk factors in addition to its relationship with osteoporosis in a Chinese population living in Lanzhou.

Methods: This cross-sectional study involved 2942 men and 7158 women aged 40–75 years who were randomly selected from 3 communities in the Lanzhou urban district and examined medically. Levels of 25-hydroxy-vitamin D [25(OH)D] and other parameters were measured according to detailed inclusion criteria. Vitamin D deficiency was defined as serum 25(OH)D levels below 20 ng/mL. Calcaneus bone mineral density (BMD) was measured by quantitative ultrasound (QUS).

Results: The prevalence of vitamin D deficiency (25(OH)D levels ≤20 ng/mL) was present in 75.2% of the entire study population. Vitamin D deficiency was more prevalent in women (79.7%) than in men (64%; P < 0.001). Multiple logistic regression analysis revealed that the significant predictors of vitamin D deficiency included coronary heart disease (CHD), obesity, dyslipidemia, older age, female sex, and smoking (all P < 0.05), whereas tea intake, moderate physical activity, milk intake, vitamin D supplementation and sun exposure were protective (all P < 0.05). No significant difference in calcaneus BMD measured by QUS was noted between subjects with <20 ng/mL and ≥20 ng/mL vitamin D levels (0.53 ± 0.13 vs. 0.54 ± 0.13; P = 0.089). The risk of having osteoporosis did not increase when vitamin D levels decreased from ≥20 ng/mL to <20 ng/mL after multiple adjustments (OR = 1.00; 95% CI 0.85–1.16; P = 0.357).

Conclusions: Vitamin D deficiency is prevalent in the middle-aged and elderly northwestern Chinese population and is largely attributed to CHD, obesity, dyslipidemia, older age, female sex, and smoking. Reduced 25(OH)D levels are not associated with an increased osteoporosis risk.

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Introduction

Osteoporotic fracture has become a major global public health problem, and it is associated with increased mortality, concomitant morbidity, and reduced quality of life [1]. China, with a rapidly developing economy and large aging population, is experiencing a growing osteoporosis pandemic [2]. Many osteoporotic risk factors have been identified. Vitamin D plays a classically important role in calcium regulation and bone metabolism [3,4]. Well-known consequences of vitamin D deficiency include secondary hyperparathyroidism, accelerated bone loss, increased bone turnover, proximal muscle weakness, increased body sway, falls, osteoporosis, and fractures [5,6]. Accumulating evidence suggests that vitamin D levels are inversely related to osteoporosis in observational studies in Western populations [7,8]; however, evidence from the Chinese population is limited [10].

The prevalence of vitamin D deficiency has increased worldwide [11]. Even in countries with plentiful sunlight, vitamin D inadequacy is observed in 64% of postmenopausal women with osteoporosis [12]. Between 40% and 100% of elderly US and European non-hospitalized men and women are classified as either vitamin D deficient or insufficient [13].

China covers a large area, and regions at different latitudes receive different amounts of sunlight. Lanzhou, which is located on the northwestern inland of China, has a temperate continental climate with different seasons (latitude of 35°5″–38°N and longitude of 102°30″–104°30″E) and is the capital of Gansu province, with a population of over 3 million. The average duration of sunshine in Lanzhou is 2446 h per year, and the average temperature is 11.2 °C [14]. Vitamin D deficiency is common in middle-aged and elderly individuals in Beijing.
and Shanghai [15]. However, less is known regarding the vitamin D status of the northern Chinese population. Furthermore, there has been no epidemiological study on the effects of vitamin D deficiency on osteoporosis and its relationship to lifestyle factors among the Lanzhou population. Thus, the main objectives of the present study were (1) to examine vitamin D status and (2) to assess risk factors for vitamin D deficiency and its relationship with osteoporosis in a representative sample of women and men aged 40–75 years in northwest China.

**Materials and methods**

**Study participants**

The present work was one part of the baseline survey from the REACTION study that investigated the association of diabetes and cancer, which was conducted among 259,657 adults aged 40 years and older in 25 communities across mainland China from 2011 to 2012 [16]. In brief, subjects were randomly selected from 3 communities in the Lanzhou urban district using stratified, multistage probability population sampling. Only persons who had been living in their current residence for at least 6 months were eligible to participate. After stratifying the population of each selected community by age, we randomly sampled subjects. The study was conducted simultaneously from May to September 2011. A total of 10,100 eligible participants (2942 men and 7158 women) were recruited. After excluding those individuals who did not have adequate blood samples \( n = 62 \), 10,038 individuals were eligible for the present analysis. The study was approved by the ethical review committee of the China CDC (the Chinese Center for Disease Control and Prevention) and the ethics committee of the First Hospital of Lanzhou University. Written informed consent was obtained from all study participants.

**Data collection**

Data collection was conducted in examination centers at community clinics in the participants’ residential area by trained staff according to a standard protocol. All subjects were medically examined and interviewed using a standardized questionnaire to collect information on age, gender, residential region, visit date (May/June/July/August/September), family history, lifestyle, dietary habits, physical activity level during leisure time, use of vitamins and medications, sunlight exposure time, coffee drinking (yes/no), smoking, alcohol drinking, self-reported diabetes, self-reported coronary heart disease (CHD), and self-reported stroke. The smoking or alcohol consumption habit was classified as never, current (smoking or consuming alcohol regularly in the past 6 months), or ever (cessation of smoking or alcohol consumption for more than 6 months). Subjects were divided into four groups based on tea consumption: group I, 0 to 4 cups of tea weekly; group II, 5–8 cups of tea weekly; group III, 9–12 cups of tea weekly; and group IV, >12 cups of tea weekly. Daily sunlight exposure was quantified based on the interview questions on frequency and length of outdoor activities, sunscreen use, and usual outdoor attire. The global physical activity questionnaire was used to assess physical activity [17]. Body weight and height were measured according to a standard protocol, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist circumference was measured on standing participants midway between the lower edge of the costal arch and the upper edge of the iliac crest. Weight was defined as normal weight (\( <24.0 \text{ kg/m}^2 \)), overweight (\( \geq 24.0 \text{ to } <28.0 \text{ kg/m}^2 \)) or obese (\( \geq 28.0 \text{ kg/m}^2 \)) according to the criteria for Chinese individuals [18]. Blood pressure was measured in the non-dominant arm 3 times consecutively with a 1-minute interval between measurements; the participants were in a seated position after 5 min of rest using an automated device (OMRON Model HEM-7071, Omron Co.). Hypertension was defined as a sitting blood pressure of at least 140 mm Hg systolic or 90 mm Hg diastolic or antihypertensive drug use.

**Serum analyses**

Blood samples were collected from all participants after an overnight fast at least 10 h and centrifuged within 30 min of collection. Serum samples remained frozen until analysis. Serum 25-hydroxyvitamin D \( [25(\text{OH})D] \) concentrations were measured by enzyme-immunoassay (EIA; IDS Ltd, UK). The intra- and interassay coefficients of variation were 7.5% and 3.9%, respectively. The measuring range for \( 25(\text{OH})D \) was 4–100 ng/mL. Circulating \( 25(\text{OH})D \) concentrations were divided into two subgroups: deficient (\( <20 \text{ ng/mL} \)) and sufficient (\( \geq 20 \text{ ng/mL} \)) [19]. Participants without a self-reported history of diabetes were given a standard 75-g glucose solution, and plasma glucose was measured at 0 and 2 h after administration during an oral glucose tolerance test. Plasma glucose was measured locally using glucose oxidase methods within 24 h. Diabetes was diagnosed according to the standard established by the American Diabetes Association (ADA) in 1997 [20]; fasting glucose \( \geq 7.0 \text{ mmol/L} \); 2-hour glucose \( \geq 11.1 \text{ mmol/L} \); or both. Dyslipidemia was defined as elevated serum cholesterol (CHOL; \( \geq 6.1 \text{ mmol/L} \)) and/or triglycerid (TG; \( \geq 2.26 \text{ mmol/L} \)) levels, and elevated LDL-cholesterol (LDL-C; \( \geq 4.14 \text{ mmol/L} \)) or decreased HDL-cholesterol (HDL-C; \( <1.0 \text{ mmol/L} \)) levels, according to the American National Cholesterol Education Program (Adult Treatment Panel III) [21]. TG, CHOL, LDL-C, and HDL-C levels were measured enzymatically on an automatic analyzer (Hitachi 7080) with reagents that were purchased from Wako Pure Chemical Industries (Osaka, Japan). Twenty-four-hour urine samples were obtained for calcium and phosphorus. Urinary creatinine was also measured to check for collection completeness. Serum and urinary calcium and phosphorus were analyzed on an automated biochemical analyzer (Dimension RxL, Dade Behring Co., Ltd, USA).

**Bone mineral density (BMD) measurements**

Right calcaneal quantitative ultrasound (QUS) measurements were taken using the Sahara clinical bone sonometer (Hologic), and two parameters (QUS-BMD and QUS-T score) were recorded. Daily calibration was performed during the entire study period, and measurements were made according to the standard procedure by a trained technician. Using this method, osteoporosis is defined as a BMD lower than \( -1.9 \text{ standard deviations (SD)} \) of the reference BMD of Caucasian women aged 20–40 years [22].

**Statistical analyses**

The results are presented as the means (±SD), and categorical variables are expressed as frequencies. With respect to the participants’ vitamin D statuses and characteristics, t-test for independent samples and one-way ANOVA were used for continuous data, and the Chi-square test was used to compare frequencies. To find the most important factors predicting the outcome of vitamin D deficiency (\( <20 \text{ ng/mL} \)), multiple logistic regression analyses were performed. All analyses regarding regression analyses were performed separately for men, women and overall. The factors were as follows: age; male vs. female; obesity (yes/no); coffee drinking (yes/no); smoking (current, former, never); alcohol consumption (current, former, never); tea consumption (group I, group II, group III, and group IV); physical activity (less, gentle, moderate, heavy); milk intake (yes/no); vitamin D supplementation (yes/no); serum phosphorus; serum Ca; urine phosphorus; urine Ca; sun exposure time; dyslipidemia (yes/no); hypertension (yes/no); type 2 diabetes mellitus (yes/no); self-reported CHD (yes/no); and self-reported stroke (yes/no). The results from the logistic regression are presented as odds ratios (OR) and 95% confidence intervals (CI). The difference in BMD based on vitamin D levels was determined,
and the influences of other variables were adjusted using an analysis of covariance (ANCOVA). A logistic regression model was used to evaluate the OR and 95% CI of having osteoporosis according to the status of 25(OH)D concentration ($\geq 20$ ng/mL; $< 20$ ng/mL) with adjustment for potential confounders. Statistical inferences were made when $p < 0.05$ (two-sided). The data were analyzed using SPSS Statistical Package (version 15.0 for Windows Smart Viewer) supplied by SPSS Inc. 2000, Mapinfo Corp. Tokyo, NY, USA.

**Results**

**Vitamin D status of the whole study population**

The overall mean (± SD) serum 25(OH)D level was 16.38 ± 6.98 ng/mL. The prevalence of vitamin D deficiency was 75.2% in the whole study population. The vitamin D status of all participants according to different characteristics is summarized in Table 1. The studied population aged 70–75 years exhibited a mean serum 25(OH)D level that was significantly lower than the studied population who were aged <70 years ($p < 0.001$). Indeed, there was a significant difference in the prevalence of vitamin D deficiency among the total population of different age groups: the prevalence of vitamin D deficiency was significantly higher in those aged 70–75 ($p < 0.001$). Moreover, men exhibited significantly higher serum 25(OH)D levels compared with women ($18.12 \pm 6.27$ vs. $15.68 \pm 7.13$ ng/mL, respectively; $p < 0.001$). Vitamin D deficiency was more prevalent in women (79.7%) than in men (64%; $p < 0.001$).

Obese subjects were associated with lower serum 25(OH)D concentrations ($p < 0.001$) and higher percentages of vitamin D deficiency ($p = 0.002$). Subjects with increased tea consumption, who were currently drinking alcohol, never smoked, and had higher physical activity levels were more likely to have higher 25(OH)D concentrations and lower percentages of vitamin D deficiency (all $p < 0.05$). Drinking coffee had no effect on vitamin D status ($p > 0.05$).

**Characteristics of study participants according to serum 25(OH)D concentrations**

Characteristics of study participants as stratified by vitamin D concentrations are demonstrated in Table 2. Participants with vitamin D levels ≥ 20 ng/mL served as the control group. Compared with control participants, individuals with vitamin D levels <20 ng/mL had a greater BMI, higher SBP, TG, and serum phosphorus levels, lower HDL-C levels, less sun exposure time, higher prevalence of dyslipidemia, and hypertension. However, there were no significant differences with regard to waist circumference, DBP, LDL-C, CHOL, serum Ca, urine phosphorus, and urine Ca levels, the prevalence of type 2 diabetes, self-reported CHD, and self-reported stroke.

**Significant predictors of vitamin D deficiency**

Multiple logistic regression analysis revealed that CHD, obesity, dyslipidemia, older age, female sex, and smoking were significant predictors of vitamin D deficiency, whereas tea intake, moderate physical activity, milk intake, vitamin D supplementation and sun exposure were protective. To examine the consistency of these associations, we performed subgroup analyses stratified by gender, and the results were consistent. The significant predictors of vitamin D deficiency in women were CHD, obesity, dyslipidemia and older age, whereas tea intake, moderate physical activity, milk intake, vitamin D supplementation, and sun exposure were protective. In men, dyslipidemia, obesity, smoking, CHD, and older age were significant predictors of vitamin D deficiency, whereas tea intake, moderate

### Table 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>25(OH)D concentrations</th>
<th>P-value</th>
<th>Vitamin D deficiency (&lt; 20 ng/mL)</th>
<th>P-value</th>
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<tr>
<td>Age (years)</td>
<td>n = 10,038</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>40–49 years</td>
<td>1832</td>
<td>16.61 (8.26)</td>
<td>&lt;0.001</td>
<td>74.2 (72.2, 76.2)</td>
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<td>50–59 years</td>
<td>3957</td>
<td>16.76 (6.11)</td>
<td></td>
<td>73.5 (72.4, 74.9)</td>
</tr>
<tr>
<td>60–69 years</td>
<td>3023</td>
<td>16.15 (7.01)</td>
<td></td>
<td>76.1 (74.5, 77.8)</td>
</tr>
<tr>
<td>70–75 years</td>
<td>1226</td>
<td>15.41 (7.36)</td>
<td></td>
<td>79.6 (77.3, 81.7)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2902</td>
<td>18.12 (6.27)</td>
<td>&lt;0.001</td>
<td>64.0 (62.2, 65.8)</td>
</tr>
<tr>
<td>Female</td>
<td>7136</td>
<td>15.68 (7.13)</td>
<td>&lt;0.001</td>
<td>79.7 (78.7, 80.6)</td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1138</td>
<td>15.53 (5.88)</td>
<td>&lt;0.001</td>
<td>78.8 (76.3, 81.1)</td>
</tr>
<tr>
<td>No</td>
<td>8900</td>
<td>16.49 (7.10)</td>
<td></td>
<td>74.7 (73.8, 75.6)</td>
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<td>Smoking</td>
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<td></td>
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<td>Current</td>
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<td>16.19 (6.84)</td>
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<td>76.4 (75.5, 77.4)</td>
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<td>Former</td>
<td>318</td>
<td>17.33 (6.28)</td>
<td></td>
<td>69.8 (64.8, 74.5)</td>
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<tr>
<td>Never</td>
<td>8404</td>
<td>17.59 (11.34)</td>
<td></td>
<td>68.5 (60.7, 76.8)</td>
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<tr>
<td>Tea drinking</td>
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<td></td>
<td></td>
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<tr>
<td>&gt;12 cups weekly</td>
<td>3168</td>
<td>16.90 (6.35)</td>
<td>&lt;0.001</td>
<td>71.3 (69.8, 72.9)</td>
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<tr>
<td>9–12 cups weekly</td>
<td>143</td>
<td>17.55 (8.42)</td>
<td></td>
<td>69.9 (62.2, 76.9)</td>
</tr>
<tr>
<td>5–8 cups weekly</td>
<td>3252</td>
<td>16.53 (7.41)</td>
<td></td>
<td>75.0 (73.6, 76.4)</td>
</tr>
<tr>
<td>0–4 cups weekly</td>
<td>3475</td>
<td>15.73 (7.01)</td>
<td></td>
<td>79.1 (77.6, 80.4)</td>
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<td>Alcohol drinking</td>
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<td></td>
</tr>
<tr>
<td>Current</td>
<td>531</td>
<td>17.47 (6.15)</td>
<td>&lt;0.001</td>
<td>68.2 (64.2, 72.1)</td>
</tr>
<tr>
<td>Former</td>
<td>2273</td>
<td>17.32 (7.13)</td>
<td></td>
<td>70.7 (68.9, 72.5)</td>
</tr>
<tr>
<td>Never</td>
<td>7234</td>
<td>16.01 (6.96)</td>
<td></td>
<td>77.1 (76.1, 78.0)</td>
</tr>
<tr>
<td>Coffee drinking</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1871</td>
<td>16.51 (6.07)</td>
<td>0.322</td>
<td>74.5 (72.0, 76.1)</td>
</tr>
<tr>
<td>No</td>
<td>8167</td>
<td>16.35 (7.17)</td>
<td></td>
<td>75.4 (74.5, 76.3)</td>
</tr>
<tr>
<td>Physical activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less</td>
<td>943</td>
<td>16.64 (6.36)</td>
<td>&lt;0.001</td>
<td>74.8 (72.0, 77.4)</td>
</tr>
<tr>
<td>Gentle</td>
<td>6505</td>
<td>16.17 (6.72)</td>
<td></td>
<td>76.1 (75.1, 77.1)</td>
</tr>
<tr>
<td>Moderate</td>
<td>2103</td>
<td>16.91 (8.03)</td>
<td></td>
<td>72.7 (70.9, 74.6)</td>
</tr>
<tr>
<td>Heavy</td>
<td>487</td>
<td>16.39 (6.62)</td>
<td></td>
<td>74.1 (70.4, 78.2)</td>
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</tbody>
</table>
The present study clearly demonstrated that vitamin D deficiency was common in Lanzhou. Moreover, in this population, we determined that CHD, dyslipidemia, older age, female sex, and smoking were independent predictors of vitamin D deficiency, especially among those who were obese. Poor 25(OH)D status was not associated with increased osteoporosis risk.

Approximately 75.2% of the whole study population exhibited a serum 25(OH)D level less than that commonly considered to represent deficiency (<20 ng/mL). Indeed, poor vitamin D status has also been identified as an independent risk factor for osteoporosis. The prevalence of osteoporosis in the whole study population was 11.2%. Osteoporosis was more prevalent in women (12.3%) than in men (8.5%; \( P < 0.001 \)). Compared with participants with vitamin D levels \( \geq 20 \text{ ng/mL} \), there was no significant increase in osteoporosis prevalence in those with vitamin D levels \( < 20 \text{ ng/mL} \) (11.5% vs. 10.1%; \( P = 0.051 \)).

The risk of having osteoporosis did not increase significantly when vitamin D levels decreased from \( \geq 20 \text{ ng/mL} \) to \( < 20 \text{ ng/mL} \) after adjustment for model 1. Further adjustments for model 2 did not materially change the association. After additional adjustments for model 3, the association did not change (Table 4).

Discussion

It is assumed that populations living in sunny locations, such as Lanzhou, northwestern China, would be less likely to be vitamin D deficient because of abundant sunshine throughout the year. However, the results of the present study challenge this assumption. The present study clearly demonstrated that vitamin D deficiency is a public health concern in Lanzhou, northwestern China.
reported previously in Chinese cross-sectional studies that were conducted in Beijing (latitude 40° north) [15] and Shanghai (latitude 31° north) [15]. The prevalence of vitamin D deficiency in our study was higher than the findings in Beijing [15] (75.2% vs. 69.2%); similarly, it was substantially higher than those observed in a Vietnamese population [23] as well as Caucasian Americans in the USA [24]. Conversely, the prevalence was lower than what has been reported for Saudi Arabian men (where 87.8% of middle-aged and elderly men had vitamin D levels lower than 20 ng/mL) [25].

Aging is associated with decreased concentrations of the precursor 7-dehydrocholesterol in the skin and thus reduced capacity to produce vitamin D [26]. After equal doses of sunlight exposure, a 70-year-old person produces 75% less vitamin D$_3$ than a 20-year-old person [27]. Therefore, a higher proportion of 25(OH)D deficiency among older people was expected. It is noteworthy that in the current study, serum vitamin D levels increased as tea consumption increased; tea consumption was protective against vitamin D deficiency. Recently, in a study performed by Abdulaziz Al-Othman et al. [28], increased tea consumption elevated circulating vitamin D levels among Saudi Arab adolescents independent of physical activity, sun exposure, age, gender and BMI [28].

The present study demonstrated that CHD, dyslipidemia, and obesity were independent predictors of vitamin D deficiency. With regard to CHD and dyslipidemia, the meaning of these findings remains unclear, but a possible explanation might be the increase in body weight, which is a condition that is frequently encountered in patients with CHD and dyslipidemia. Previous studies have demonstrated that obesity [26,27] is associated with lower serum 25(OH)D levels. In our study, the obese population demonstrated mean serum 25(OH)D levels that were significantly lower than the non-obese population. The inverse relationship between 25(OH)D levels and obesity may be because of a larger body pool of vitamin D and 25(OH)D, or to a slower saturation and mobilization of these metabolites from adipose tissues, or both. Thus, obese individuals have lower vitamin D bioavailability from cutaneous and dietary sources because of a tendency for vitamin D to deposit in adipose tissue [29]. In obese subjects, the increase in blood vitamin D concentrations is smaller than in non-obese individuals after an oral dose of vitamin D or following sunlight exposure [29]. Furthermore, in diseases that cause disability such as CHD or stroke, reduced outdoor activity might induce low vitamin D levels, which has been linked to calcium malabsorption and may cause secondary hyperparathyroidism. Secondary hyperparathyroidism contributes to accelerated bone loss and/or bone turnover and predisposes the population to fragility fractures [4]. Furthermore, the present study demonstrated that the above factors together with smoking in men are independent predictors of vitamin D deficiency, and the cumulative effects of such factors were impressive, whereas tea intake, moderate physical activity, milk intake, vitamin D supplementation and sun exposure were protective factors against vitamin D deficiency. Such an observation suggests that subjects with these risk factors will particularly benefit from higher vitamin D supplementation and/or food fortification and increased sunshine exposure and tea consumption. Therefore, clinical trials are warranted to assess the possible potential beneficial effects.

We used QUS to assess bone health rather than dual X-ray absorptiometry (DXA) because QUS has many advantages over DXA, such as lower cost, no ionizing radiation, simplicity, and portability. Furthermore, several studies have demonstrated that osteoporotic fracture prediction by QUS was equal to and possibly better than DXA [30,31]. BMD variation in a specific population is affected by between-individual variations in body size, bone size, genetics, physical activities, habitual diets, certain health-related behaviors, and other factors that may influence BMD [2]. The prevalence of osteoporosis was 12.3% in females, 8.4% in males, and 11.2% in the total studied population. Age, gender, and body weight have been implicated as osteoporosis risk factors [32]. The gender differences in osteoporosis prevalence were remarkable in our study. Average BMD levels were higher in men compared with women, which could be related to decreased estrogen levels at menopause [33]. Higher BMD values and slower bone decline rates might partially contribute to the reduced prevalence of osteoporosis in men [2].

The role of vitamin D in the maintenance of bone health has been well documented in various populations. A direct association between bone mineral status and 25(OH)D has been observed by some investigators [7,8,25,34] but not by others [9,10]. In our study, we observed no significant correlation between serum 25(OH)D levels and BMD values measured by QUS; poor 25(OH)D concentrations did not increase osteoporosis risk among the Lanzhou population.

Because there is evidence of ethnic variation in the 25(OH)D effect and limited data on the association of 25(OH)D with osteoporosis in Chinese persons, our data provide novel insights into the nature of this association among the Chinese. Nevertheless, the study has some potential weaknesses. First, the main limitations of the present study were its cross-sectional design; hence, no causal inferences could be made for the observed relationships between factors. Second, the possibility of selection bias also arose, and the accuracy of self-reported data related to lifestyle factors may have been subject to report bias; thus, there may be unrecognized confounding factors. Finally, because we did not measure parathyroid hormone, we could not determine whether the association of 25(OH)D with osteoporosis was partly mediated by secondary hyperparathyroidism. It is now well recognized that genetic factors are also important contributors to variation in plasma vitamin D concentrations [35]; however, few genetic studies have related to vitamin D levels in Chinese populations [36,37]. Recent studies have identified common variants in or near GC, CYP2R1 and NADSYN1/DHCR7 to be associated with decreased plasma 25(OH)D levels in Chinese Han from Beijing and Shanghai [37], and it remains to be confirmed whether they have similar effects in northwest China. Thus, further studies are needed to review these variants in a population-based cohort of Chinese Hans from Lanzhou.

Conclusions

In summary, vitamin D deficiency is very common (75.2% with 25(OH)D <20 ng/mL) in a middle-aged and elderly Chinese northwestern population, particularly functional disability among those who were women, obese, and age 70–75 years with CHD or dyslipidemia, corresponding to 79.7% of women and 64% of men. Other factors include smoking in men. Moreover, reduced 25(OH)D levels were not associated with an increased osteoporosis risk.

Acknowledgments

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References


