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Original Article

A cross-sectional study of bone density and associated factors among community dwelling men

Yin-Ming Li [a,b,*], Hui-Ling Lai [b]

[a] Department of Family Medicine, Buddhist Tzu Chi General Hospital, Hualien, Taiwan
[b] Department of Nursing, Tzu Chi University, Hualien, Taiwan

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ABSTRACT

Objective: Osteoporosis in men is substantially underestimated and undertreated worldwide. Therefore, our study aimed to assess the bone mineral density (BMD) and predicting factors of low BMD in community dwelling men.
Materials and Methods: This cross-sectional study was conducted from January 2004 to November 2005. The participants were 519 men from 30 to 79 years old who underwent a checkup at a teaching hospital in eastern Taiwan. Anthropometric and lifestyle factors were investigated using a standard self-reporting questionnaire. Bone mineral density of the posterior-anterior lumbar spine (L1–L4) (BMD_L) was measured by dual energy X-ray absorptiometry. Age groups were stratified by 10-year intervals.
Results: The mean BMD_L in the 519 participants was 0.951 g/cm^2, with no significant difference between age groups. The BMD_L was correlated positively with body mass index (BMI) ($r = 0.22$, $p < 0.001$). Of the 390 men aged 50 or older, 17.4% had an osteoporotic lumbar spine. Their mean age was 59.4 years [standard deviation (SD) 6.3], with a mean BMD_L of 0.758 g/cm^2, and a mean BMI of 23.1 (SD 3.5). Low body mass was noted as the unique factor associated with osteoporosis in a mutlivariate analysis, after controlling for risk factors such as aging, smoking, alcohol intake and low physical activity. Men with a BMI less than 22.9 (the 25th percentile) were 2.9 times more likely to have osteoporosis than those with a higher BMI.
Conclusion: Low bone mass is not uncommon in men in Taiwan. A low body mass index was a risk factor. Further investigation of both the bone health of men and the effects of environmental factors is crucial.

1. Introduction

As the aged population rises dramatically, osteoporosis is a growing health concern globally. In Taiwan, the burden of osteoporotic fracture has been noted in previous studies with about 12% of men in urban districts experiencing one or more vertebral compression fractures in 1993 [1]. According to Taiwan national health insurance data, the estimated incidence of hip fracture in men was 225 per 100,000 population or about 5000 hospitalizations of men for hip fractures from 1999 to 2000 [2].

Osteoporotic facture leads to significant morbidity and mortality [3], and poor functional outcomes [4,5] are well demonstrated from women's studies. Those fractures are also associated with great socioeconomic burden [6]. Moreover, fractures in men result in a higher morbidity and mortality than those observed in women [7,8]. Osteoporosis is no longer regarded as an inevitable result of aging but as a preventable and treatable disorder [9]. However, osteoporosis in men is substantially under-diagnosed and under-treated worldwide [10]. Its occurrence is determined by many factors, notably lifestyle, medications, genetic susceptibility, and interactions between these factors [9,11]. Low bone mass has been defined as an intermediate risk factor, similarly to prehypertension in heart disease. In Taiwan, the life expectancy of men has increased remarkably in the last decade, rising from 71.9 years in 1995 to 76.4 years in 2010 [12]. Several studies have tried to identify the main determinants of low bone mineral density (BMD) in men. However, the most recent populations studied were elderly men [13,14]. The aim of this cross-sectional study was to assess the BMD and risk factors for low BMD in community dwelling men.

2. Materials and methods

This cross-sectional study was carried out from January 2004 to November 2005 at a teaching hospital of the Buddhist Compassion

Conflict of interest: none.

* Corresponding author. Department of Family Medicine, Buddhist Tzu Chi General Hospital, 707, Section 3, Chung-Yang Road, Hualien, Taiwan. Tel.: +886 38 561825x2134; fax: +886 38 577161.
E-mail address: yinming@mail.tcu.edu.tw (Y.-M. Li).

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Relief Tzu Chi Foundation in eastern Taiwan. Healthy participants of 30–85 years old who were receiving a health checkup, were invited to participate in this study. Most participants were volunteers from the Foundation and had free medical checkups every 2 years. All participants gave their consent for analysis of data, and the project was approved by the Protection of Human Subjects Institutional Review Board of Tzu Chi University and Hospital. In this paper, men from 30 to 79 years old were studied. A total of 532 men were enrolled. Thirteen (2.4%) participants were excluded because they had a history or evidence of metabolic bone disorders, were taking medication such as thyroid hormone, or had a history of steroid use.

2.1. Data collection

Data on background characteristics, lifestyle (smoking, alcohol intake), frequency of physical activity and diet were collected with a standard self-reporting questionnaire. Medical history (i.e., asthma, hypertension, diabetes, thyroid problems) and medications (use of oral steroids) were also assessed.

Weight was measured without shoes in light indoor clothing, using a calibrated digital scale. Height was measured using a calibrated stadiometer. BMD was assessed by measurements taken at the lumbar spine by dual energy X-ray absorptiometry (DXA) using a Hologic QDR 4500W densitometer (Hologic, Inc., Waltham, MA, USA). The coefficient of variation of our machine was 1%. Quality control procedures were carried out in accordance with the manufacturer's guide. The mean value of the bone density of the lumbar spine (L1–L4) was labeled as the subject's BMD_L. For participants 50 years old or older, the assessment of the BMD_L was also categorized by T-score into three groups with T-scores of ≥ -1.0 defined as "normal", < -1.0 to -2.5 as "low bone mass", and ≤ -2.5 as "osteoporosis" according to the World Health Organization criteria [9].

Smoking was categorized as never smoked, ex-smoker, and current smoker; physical activity was assessed as high, moderate or low if the subject exercised daily, 3 times or more or 2 times or less per week, respectively. Vegetarianism was defined as a lacto- or ovo- or both vegetative diet. Low physical activity, current smoker, current alcohol drinker, and vegetarian diet were categorized as lifestyle risk factors. Hypertension, adult diabetes mellitus, and heart disease on the self-reported medical history were defined as medical risk factors. Low body mass was defined as a body mass index (BMI) less than the 25th percentile [15]. Education for 12 years or more was defined as high education.

2.2. Statistical analysis

Means, standard deviations (SD) and Student t test were used to compare numerical variables. The age specific mean and SD of the BMD_L were calculated for age groups stratified by 10-year intervals. The Mantel–Haenszel (M–H) chi-square test for trend was computed to assess the effect modification of the association between age and bone density. Pearson correlation coefficients of bone density and each potential covariate were computed independently. Comparison between participants was done using analysis of variance (ANOVA) for quantitative variables and the chi-square test for qualitative variables. Stepwise multiple regression analysis was then used to study the determinants of BMD_L. Frequency, percentages and 95% confidence intervals (CI) were used to assess the prevalence of osteoporosis. Logistic regression analysis was employed to estimate the multivariate-adjusted odds ratio of the independent variables. SAS software 9.12 (Cary, NC, USA) was used for statistical analysis and p values < 0.05 were considered statistically significant.

3. Results

The mean age of the 519 men was 55.9 years (SD 9.5), and 18.9% were 65 years old or older. The mean body weight was 69.6 kg (SD 10.3) and mean height was 166.4 cm (SD 6.4). The general characteristics of the participants are shown in Table 1. One-third (27.4%) of the men were ex-smokers, 16.0% were current smokers and 56.1% had never smoked. About one in five men reported that they currently drank alcohol. Eighty-seven men (16.8%) were vegetarians. In total, 140 (27.0%) reported they had hypertension and 9.1% had heart disease. About one-third had a high education level.

The mean BMD of all participants was 0.951 g/cm^2 (SD 0.132), which was not significantly correlated with age ($r = -0.02$, $p = 0.59$). The mean BMI was 25.1 (SD 3.3), which was positively correlated with the BMD_L ($r = 0.22$, $p < 0.01$) and negatively correlated with age ($r = -0.11$, $p = 0.01$). The 25th and 75th percentiles of the BMI were 22.9 and 26.8, respectively. The mean BMD and BMI were lower in the oldest age group (70–79 years) but no significant difference was noted (Table 2). The BMD_L was positively correlated with the BMI among men less than 50 years old ($r = 0.35$, $p < 0.01$) and men 50 years old or older ($r = 0.17$, $p < 0.01$) (data not shown). Multiple linear regression analysis was performed to identify the related factors that affected BMD_L. The independent parameter associated with BMD_L was the BMI (standardized coefficient = 0.31, $p < 0.01$). The adjusted R^2 value of the regression model was 4.3%.

Among men 50 years old or older, the prevalences of lifestyle risk factors were as follows: current smokers 13.1%, current alcohol drinking 18.7%, ex-smoker 29.2%; low physical activity 54.1%; and vegeterianism 16.4%. The prevalences of osteoporosis and low bone mass were 17.4% (95% CI: 13.6, 21.2) and 44.1% (95% CI: 39.2, 49.0), respectively. The results of DXA testing showed no significant differences in men, 50–59 years, 60–69 years and 70–79 years old (the M–H chi-square test for trend was 1.64, $p = 0.47$). Surprisingly, men 50–59 years old had a high prevalence of osteoporosis (19.6%, 95% CI 14.3, 24.9). The 68 men diagnosed with osteoporosis had

Table 1
Life style and medical illness of the 519 men.

Life style	*n*	%
Tobacco use		
Current smokers	83	16.0
Ex-smokers	142	27.4
Never	291	56.1
Missing	3	0.6
Alcohol drinking		
Current drinkers	107	20.6
Ex-drinkers	100	19.3
Never	203	39.1
Missing	109	21.0
Betel nut chewing		
Current chewers	27	5.2
Ex-chewers	72	13.9
Never	411	79.2
Missing	9	1.7
Physical activity		
High (daily)	131	25.2
Moderate ($\geq$ 3 times/w)	72	13.9
Low ($<$ 3 times/w)	316	60.9
Vegeterian diet	87	16.8
Currently calcium supplement	87	16.8
Medical illness		
Hypertension	140	27.0
Type II diabetes	33	6.4
Heart disease	47	9.1
Asthma	16	3.1

Table 2
Body mass index and results of lumbar mineral bone density testing[a] by age groups.

Age (y)	*n*	Age mean ± SD	Body mass index[b] mean ± SD	Bone density[c] (g/cm^2) mean ± SD	Low bone mass *n* (%)	Osteoporosis *n* (%)
39–39	22	35.4 ± 2.6	26.1 ± 3.7	0.964 ± 0.107		
40–49	107	45.9 ± 2.6	25.6 ± 3.7	0.968 ± 0.120		
50–59	219	54.5 ± 2.8	24.9 ± 3.2	0.935 ± 0.127	99 (45.2)	43 (19.6)
60–69	126	64.2 ± 2.7	24.9 ± 3.0	0.966 ± 0.146	52 (41.3)	18 (14.3)
70–79	45	73.3 ± 2.7	24.6 ± 2.6	0.941 ± 0.148	21 (46.7)	7 (15.6)
All	519	55.9 ± 9.5	25.1 ± 3.3	0.951 ± 0.132		

[a] Criteria of WHO T-score. Normal group ≥ −1.0; low bone mass < −1.0 to −2.5; osteoporosis ≤ −2.5.
[b] Body mass index (kg/m^2): ANOVA test F value = 1.74, $p = 0.14$.
[c] Bone mineral density (g/cm^2): ANOVA test F value = 1.78, $p = 0.13$.

a mean age of 59.4 years (SD 6.3), mean BMD_L of 0.758 g/cm^2, mean BMI of 23.5 (SD 3.5) and mean body weight of 64.1 kg (SD 10.0). Age 65 years old and older, low body mass and other known risk factors of osteoporosis, such as current smoking, and alcohol drinking were used as independent variables in the logistic regression model. The analysis revealed that low body mass was the significant factor associated with osteoporosis (Table 3). Those with a BMI less than 22.9 (the 25 th percentile) were 2.9 times more likely be diagnosed with osteoporosis ($p < 0.01$) than those with a higher BMI. Results of DXA testing across different quartiles of the BMI (M–H chi-square = 17.5, $p < 0.01$) are shown in Fig. 1. Current smoking was more prevalent among men with normal bone density (14%) than those with osteoporosis (11.8%). The prevalence of current alcohol drinkers was 19%, no difference between men had normal bone mass or had osteoporosis. No significant differences in lifestyle or medical risk factors were found between participants with different DXA testing results.

4. Discussion

In this study, we found that the average mean BMD_L of men 30–39 years old was 0.964 g/cm^2. Our results were similar to findings from mainland China (0.957 g/cm^2) [16] and India (0.947 g/cm^2) [17]. In previous reports from Taiwan, the mean BMD_L of men aged 30–39 years was found to be 1.22 g/cm^2 in 1988 [18], 1.057 g/cm^2 in 2000 [19], 1.009 g/cm^2 in 2004 [20], and 0.97 g/cm^2 from 2005 to 2008 [21]. Our finding raises concerns about whether and why Taiwanese young men have low bone density. In a study of male resident doctors in India, factors associated with low bone density were low BMI, reduced bioavailability of dietary calcium and inadequate physical activity [17]. So, further studies of the bone health of Taiwanese young men and the effects of environmental factors are needed.

The low BMI in the elderly may be due to decreased lean mass and dehydration of the intervertebral disks associated with aging. Previous studies suggest that in men, bone loss accelerates after the age of 70 years [13,16,20]. However, we found the BMD_L decreased only slightly with increasing age. Vertebral osteoarthritis and a calcified aortic wall may elevate BMD_L, which could explain this discrepancy. Panel experts recommend that bone density testing should be performed simultaneously in the spine and hips [15,22]. Further bone density studies in the elderly should include hip bone testing.

The prevalence of osteoporosis among men 50 years old or older was 17.4%. Our results differ from the results of the Nutrition and Health Survey in Taiwan 2005–2008, which reported 4.3% of these men had osteoporosis in the lumbar spine and a total of 23.9% had involvement in the lumbar spine, hip femoral neck or forearm [19]. Since the study cohort and their background were different, comparison of the results may not be appropriate. From an epidemiological view, bias in the prevalence estimation with different numbers of age groups must be considered. DXA bone density testing is not a convenient test and is not recommended for men without major risk factors in Taiwan. Our results can be used as a reference for bone health consultation for men.

Osteoporosis in men often has secondary causes such as excessive alcohol use, smoking or corticosteroid therapy [23]. As this was a cross-sectional study, we did not know our participants' peak bone mass. We could not determine whether the high prevalence of abnormal bone density tests occurred because of low peak bone mass or bone loss afterwards. Nearly half of our participants had a history of tobacco and alcohol use. Also, one out of six was vegetarian and more than half had low physical activity. The high prevalence of low bone mass might have occurred because of the high exposure rate of substance use, low physical activity or a vegetarian diet. We did not collect information about the quantity of substances used so we could not accurately estimate their effects.

Table 3
Logistic regression analysis on variables associated with osteoporosis.[a]

Variables	Estimate	Standard error	Odds ratio estimates Point estimate	95% CI
Intercept	−1.69	0.43		
Old age (≥ 65 years)	−0.33	0.36	0.72	0.36–1.45
Body mass index < 22.9 (the 25th percentile)	1.07	0.28	2.91	1.67–5.10
Low physical activity (< 3 vs. ≥3 times/w)	−0.18	0.29	0.83	0.47–1.47
Current smokers (yes vs. no)	−0.36	2.30	0.70	0.39–1.24
Current alcohol drinkers (yes vs. no)	−0.02	0.29	0.98	0.56–1.73
Vegetarian diet (yes vs. no)	0.13	0.39	1.14	0.53–2.49

[a] Number of observations = 390, 68 men diagnosed with osteoporosis. Likelihood chi-square = 18.57, DF = 6, $p = 0.005$. $R^2 = 0.0488$. Hosmer–Lemshow goodness of fit: chi-square = 8.619, DF = 8, Pr > Chisq = 0.4274.

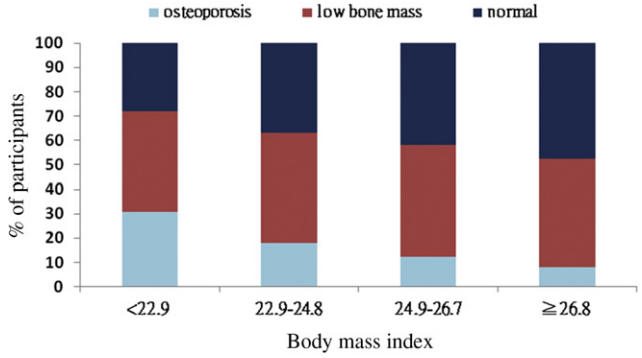

Fig. 1. Results of bone density testing with dual energy X-ray absorptiometry by body mass index.

A lack of a detailed history of substance use limited our assessment. These limitations should be overcome in future studies.

In our study, the adjusted predictive accuracy of the BMD_L was low and lifestyle risk factors such as aging, smoking, alcohol intake and low physical activity were not statistically significant. This finding was similar to a previous study in northern Taiwan [17]. Bone remodeling in men is different from that in women [24]. Further investigation of factors associated with bone loss in men is crucial.

We found that low body mass was the factor associated with osteoporosis. The BMI was negatively associated with the BMD_L; this is consistent with other studies [25,26]. Indeed, low body weight is a well-known major risk factor for osteoporosis, with an increased fracture risk. So maintaining an ideal body weight is important, and is particularly crucial in young adults to achieve an adequate peak bone mass.

Our study had limitations. First, our sample is from one hospital and most participants were volunteers from a charity organization. The findings cannot be extrapolated to the general population. Second, our data is cross-sectional so a causal inference between risk factors for low bone mass cannot be assessed. Third, we did not include some major risk factors that may affect BMD_L, for example, a detailed dietary calcium intake or a family history of fragility fractures. Fourth, information about lifestyle was self-reported so recall bias may also be a concern. And finally, errors in spinal DXA because of degenerative changes in the spine should be considered. In conclusion, low bone mass was not uncommon in men and low body mass was a predicting risk factor. Further investigation of both bone health in men and the effect of environmental factors is crucial.

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