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ORIGINAL ARTICLE

Reference ranges for vertebral heights and prevalence of asymptomatic (undiagnosed) vertebral fracture in Vietnamese men and women

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Abstract
Summary Based on quantitative measurements of vertebral heights, the prevalence of undiagnosed vertebral fracture in Vietnamese men and women aged 50 years and older was 23 and 26 %, respectively
Background The present study sought to develop reference ranges for vertebral heights and to determine the prevalence of asymptomatic vertebral fracture in Vietnamese men and women.
Methods The study included 312 men and 657 women aged over 18 who were randomly selected from the community. The ImageJ software program was used to measure anterior height (H_a), middle height (H_m), and posterior height (H_p) for each vertebra (T4 to T12 and L1 to L5). Four vertebral ratios were determined: H_a/H_p, H_m/H_p, H_p/H_{p+1}, and H_p/H_{p-1}. Reference ranges for the ratios were then developed by the method of Winsorized mean. Vertebral fracture was diagnosed as a ratio lower than three standard deviations from the normal mean.
Results For any given vertebra, H_a, H_m, and H_p in men were higher than in women. In both sexes, H_a and H_m increased in a stepwise fashion from T4 to L3 and then gradually reduced in L4–L5. Vertebral heights for T4–T9 tended to decrease, while vertebral height for T10–L5 tended to increase with advancing age. Among those aged over 50 years, the prevalence of vertebral fracture in men was 23.3 % (95 % confidence interval (CI) 16.8–31.3 %) which was lower than that in women (26.5 %; 95 % CI 22.4–31.1 %). The prevalence increased with advancing age, such that from the age of over 70, 41 % of men and 42 % women had at least one vertebral fracture.
Conclusion One fourth of Vietnamese men and women aged 50 years and older have a symptomatic vertebral fracture. This prevalence is equivalent to that in Caucasian populations.

Keywords Osteoporosis · Bone mineral density · Vertebral fracture · Vertebral height · Reference range

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Introduction

Vertebral fracture is a classic manifestation of osteoporosis [1] and is associated with serious clinical consequences.

Most vertebral fractures have no apparent symptoms, with up to 70 % of cases being not detected [1–4]. Vertebral fracture is associated with serious clinical consequences, including substantial back pain, physical impairment, and disability [5–7], which are in turn associated with reduced quality of life [8, 9] and increased risk of mortality [10, 11]. In addition, a preexisting vertebral fracture is a clinical indicator of future nonvertebral fractures [12–15], such that individuals with a vertebral fracture have a 5-fold increase in subsequent fracture risk [16]. Therefore, identifying individuals at high risk of vertebral fracture is an important step in the prevention and treatment of osteoporosis in the general community.

Currently, there are two main approaches to the diagnosis of vertebral fracture: semiquantitative and quantitative methods [17]. The semiquantitative method is commonly used in clinical practice, but it can result in false-positive and false-negative diagnoses because of intra- and interobserver variability. The semiquantitative method can be effectively used in an individual patient, but it becomes inefficient when applied to a large population [18, 19]. Quantitative morphometry offers a more objective and reproducible approach [20]. However, the quantitative method requires a population reference range of vertebral dimensions for accurate diagnosis of vertebral fracture.

While the prevalence of, and risk factors for, asymptomatic vertebral fracture in Caucasians have been well documented, few data are available for non-Caucasian populations. Several studies have suggested that the prevalence of vertebral fracture ranged from 10 to 25 % in women and between 10 and 27 % in men [21–27], with a high variability among countries and ethnicities. The prevalence also increased with age in both men and women though the gradient was steeper in women [21]. However, data on the prevalence and risk factors for vertebral fractures in Asians are limited. Recent epidemiologic studies in Thailand and China observed a prevalence of 10 and 30 %, respectively [28–31]. Our previous study on postmenopausal vegetarian women in Vietnam (using semiquantitative method) found that 23 % of postmenopausal women had at least one vertebral fracture [32]. Underreporting and underrecognition of vertebral fracture have led to lack of clinical care and complication in the management of osteoporosis in Asian countries.

Vietnam is a relatively large country in Southeast Asia with a population of 86 million. Like other countries in the region, there are virtually no population-based fracture data in Vietnam. In an effort to contribute to the international literature of osteoporosis, we undertook this study to (a) develop reference ranges for vertebral heights and (b) ascertain the prevalence of asymptomatic (undiagnosed) vertebral fractures in men and women.

Study design and methods

Study design and participants

The study was designed as a cross-sectional investigation, with the setting being Ho Chi Minh City, a major city in Vietnam [33]. The research protocol and procedures were approved by the Scientific Committee of the People's Hospital 115 and Pham Ngoc Thach University of Medicine. The study procedure was in accordance with the principles of medical ethics of the World Health Organization. All participants were provided with full information about the study's purposes and gave written informed consent to participate in the study.

We approached community organizations, including church and temples, and obtained the list of members and then randomly selected individuals aged 18 or above. We used simple random sampling technique to identify potential participants. We sent a letter of invitation to the selected individuals. Some participants were invited via phone. The participants did not receive any financial incentive, but they received a free health checkup and lipid analyses. Participants were excluded from the study if they had diseases deemed to affect bone metabolism such as hyperthyroidism, hyperparathyroidism, renal failure, malabsorption syndrome, alcoholism, chronic colitis, multiple myeloma, leukemia, and chronic arthritis.

Measurements and data collection

Data collection was done by trained research doctors and nurses using a validated questionnaire. The questionnaire solicited information, including anthropometry, lifestyle factors, dietary intakes, physical activity, and clinical history. Anthropometric parameters including age, weight, and standing height were obtained. Body weight was measured on an electronic scale with indoor clothing without shoes. Height was determined without shoes on a portable stadiometer with the mandible plane parallel to the floor. Each participant was asked to provide information on current and past smoking habits. Smoking was quantified in terms of the number of pack-years consumed in each 10-year interval age group. Alcohol intake in average numbers of standard drinks per day, at present as well as within the last 5 years, was obtained. Clinical data including blood pressure, pulse, reproductive history (i.e., parity, age of menarche, and age of menopause), and medical history (i.e., previous fracture, previous and current use of pharmacological therapies) were also obtained.

Determination of reference ranges for vertebral heights

Standard lateral and anterior–posterior thoracic and lumbar spine radiographs were taken with a 101.6-cm tube-to-film distance and were centered at L2. In each individual, vertebral morphometry was performed by using Image J software to measure anterior (H_a), middle (H_m), and posterior (H_p) height for each vertebra from T4 to L5. Then the following ratios were calculated: H_a/H_p, H_m/H_p, H_{pi}/H_{pi-1}, and H_{pi}/H_{pi+1}. We determined six points corresponding to the four corners of the vertebral body and the midpoints of the endplates, using the method described by Smith Bindman et al. [34].

In order to assess the interobserver variability, we randomly chose 350 radiographs, which were then read by two doctors. The coefficient of reliability between the two doctors ranged between 0.81 and 0.94 in vertebral heights. In order to assess intraobserver variability, 50 radiographs were randomly selected, and each doctor read the radiographs in two occasions separated by 4 weeks. The intraobserver coefficient of reliability was consistently greater than 0.90.

The first objective of this study was to determine means and standard deviations (SD) of the height ratios H_a/H_p, H_m/H_p, H_{pi}/H_{pi-1}, and H_{pi}/H_{pi+1} for each vertebra. The Winsorized mean method [35] was used to calculate the means and SD for each vertebra. In this method, the effect of "outliers" (if there are) could be neutralized and therefore yields a more stable estimate of standard deviation. Each variable was first tested for normal distribution by using Shapiro–Wilk's test, and then the smallest and largest values were replaced with the observations closest to them. Simple arithmetic means and standard deviation were then estimated from the sample.

Definition of vertebral fracture

Morphometric vertebral fracture was defined according to the method initially suggested by Riggs et al. [36] and was refined by Eastell et al. [37]. In this method, four ratios are calculated as follows: the wedge ratio (H_a/H_p), midwedge ratio (H_m/H_p), and two crush ratios (H_{pi}/H_{pi-1}, H_{pi}/H_{pi+1}) in which H_{pi+1} and H_{pi-1} refer to the H_p of the vertebrae immediately above and below the vertebra of interest. A vertebra was defined as "fracture" if at least one ratio fell three SDs or more below the normal reference mean for that ratio at that vertebral level. Based on the ratios that identified the vertebra, fracture was further classified into wedge, midwedge, or crush.

The prevalence of vertebral fracture was estimated for individuals aged 50 years and older. Overall rate of fracture and age-specific rates were estimated for any fracture as well as for each type of fracture. The estimation was done for men

Table 1 Demographic and clinical characteristics of participants

	Men (N=312)	Women (N=657)
Age (years)	43.6 (18.6)	58.7 (11.8)
Weight (kg)	61.9 (9.5)	53.2 (7.8)
Height (cm)	165.0 (6.6)	151.3 (5.8)
BMI (kg/cm^2)	22.7 (3.0)	23.2 (3.7)
Smoking (%)		
Yes	38.8	98.6
No	61.2	1.4
Diabetes (%)		
Yes	93.0	92.2
No	7.0	7.8
History of fracture (%)		
Yes	76.7	73.5
No	23.3	26.5

Values are mean and standard deviation (in brackets)

Table 2 Vertebral heights H_a, H_m, and H_p in men and women

Vertebra	H_a		H_m		H_p	
	Mean	SD	Mean	SD	Mean	SD
Women						
T4	19.07	1.44	17.96	1.48	20.12	1.62
T5	19.57	1.53	18.46	1.50	20.78	1.64
T6	19.85	1.47	18.90	1.55	21.30	1.65
T7	20.19	1.60	19.30	1.58	21.73	1.63
T8	21.11	1.73	19.79	1.59	21.97	1.63
T9	22.13	1.60	20.56	1.52	22.58	1.75
T10	22.92	1.77	21.72	1.73	23.80	1.99
T11	23.73	2.11	23.03	2.06	25.60	2.28
T12	25.37	3.07	24.86	2.86	27.55	2.51
L1	26.98	2.78	26.34	2.52	28.68	2.31
L2	28.99	2.68	27.35	2.37	29.34	2.38
L3	29.61	2.44	28.03	2.18	29.20	2.27
L4	28.94	2.54	27.71	2.21	27.75	2.40
L5	28.90	2.81	26.81	2.43	25.84	2.47
Men						
T4	21.70	1.59	20.65	1.62	22.97	1.75
T5	22.23	1.57	21.27	1.65	23.56	1.88
T6	22.60	1.70	21.79	1.61	24.01	1.80
T7	22.97	1.73	22.15	1.63	24.36	1.86
T8	23.66	1.70	22.52	1.68	24.45	1.85
T9	24.73	1.86	23.12	1.62	24.69	1.90
T10	25.74	1.87	24.21	1.77	25.89	2.09
T11	26.26	2.09	25.58	1.91	27.91	2.38
T12	27.68	2.17	27.56	2.22	30.13	2.42
L1	29.02	2.41	29.38	2.05	32.20	2.19
L2	30.90	2.40	30.22	2.21	32.72	2.45
L3	31.68	2.51	30.84	2.20	32.23	2.33
L4	31.23	2.71	30.43	2.45	30.53	2.54
L5	31.43	2.55	29.21	2.40	28.35	2.69

and women separately. The 95 % confidence interval (CI) of the prevalence rate was estimated by the Bayesian method [38]. All statistical analyses and data management were performed with R statistical environment [39].

Results

The study included 969 individuals (312 men and 657 women) aged between 18 and 87 years (mean, 54 years), among whom 525 individuals (129 men and 396 women) were aged 50 years and older. The demographic and clinical characteristics of all participants are shown in Table 1. Approximately 61 % of men and 1.4 % of women reported being current smokers. As expected, men had greater height and weight than women, but there was no significant difference in BMI between the two genders. Moreover, the prevalence rates of diabetes and fractures were not significantly different between men and women.

Reference ranges for vertebral heights

For a vertebra, H_a, H_m, H_p in men were consistently higher than in women by between 1 and 2 mm (Table 2). In both genders, vertebral height H_a and H_m increased in a stepwise fashion from T4 to L3 and then gradually reduced in L4–L5. Similarly, posterior H_p also increased from T4 to L2 and decreased from L3 to L5. At each vertebra, posterior height was generally higher than the anterior one, and middle height was the lowest $H_p > H_a > H_m$, but from L3 in women and L4 in men, the H_p decreased leading $H_a > H_p > H_m$, and at L5, H_p was the lowest in the two sexes and $H_a > H_m > H_p$.

Analysis by age showed that in women, vertebral heights for T4–T9 tended to stabilize while vertebral height for

Table 3 Changes of vertebral heights H_a, H_m, and H_p by age in men and women

Vertebra	H_a			H_m			H_p		
	<50	50–69	70+	<50	50–69	70+	<50	50–69	70+
Women									
T4	19.10	19.43	19.54	17.77	18.33	18.17	20.87	20.38	20.65
T5	19.72	19.91	19.81	19.69	18.80	18.43	19.94	21.11	20.88
T6	17.14	20.24	19.95	17.82	19.31	18.93	21.64	21.53	21.57
T7	20.37	20.53	20.51	19.71	19.73	19.35	22.39	22.01	22.03
T8	21.26	21.44	21.04	20.37	20.19	19.69	21.24	22.29	22.16
T9	22.24	22.51	22.23	21.15	21.00	20.70	23.28	22.93	22.95
T10	23.67	23.26	22.90	23.47	22.20	21.86	25.88	24.20	24.28
T11	25.17	24.33	23.34	26.00	23.71	22.75	28.50	26.13	25.77
T12	28.25	26.14	24.50	27.18	25.75	23.77	29.01	28.17	27.09
L1	27.74	27.55	27.45	27.69	26.99	26.36	29.84	29.27	28.59
L2	29.07	29.57	28.99	26.84	28.17	26.83	30.34	30.07	29.39
L3	30.01	30.18	29.66	27.17	28.82	27.53	31.71	30.00	29.02
L4	32.26	29.52	28.82	30.52	28.53	27.26	30.38	28.68	27.38
L5	27.21	29.75	28.86	26.53	27.76	26.82	21.62	26.70	25.73
Men									
T4	21.98	21.47	20.85	21.02	20.38	19.40	23.22	22.84	22.03
T5	22.46	22.00	21.64	21.59	20.99	20.33	23.73	23.46	22.92
T6	22.77	22.51	21.90	22.03	21.60	20.95	24.08	24.01	23.60
T7	23.12	22.84	22.51	22.30	22.05	21.58	24.38	24.43	24.07
T8	23.77	23.55	23.37	22.61	22.44	22.26	24.43	24.51	24.35
T9	24.83	24.70	24.23	23.15	23.11	22.97	24.56	24.77	25.21
T10	25.89	25.75	24.87	24.25	24.29	23.74	25.64	26.11	26.56
T11	26.40	26.25	25.53	25.64	25.63	25.09	27.69	28.12	28.49
T12	27.92	27.39	27.23	27.75	27.45	26.82	30.13	30.14	30.10
L1	29.36	28.45	28.78	29.70	29.00	28.76	32.46	32.02	31.29
L2	31.37	30.42	29.72	30.63	29.88	28.98	32.90	32.69	31.82
L3	32.11	31.15	30.86	31.26	30.44	29.63	32.27	32.35	31.67
L4	31.77	30.50	30.34	30.89	30.02	29.00	30.71	30.55	29.49
L5	31.90	30.72	30.86	29.75	28.71	27.70	28.85	27.85	27.02

Table 4 Parameters H_a/H_p, H_m/H_p, H_{pi}/H_{pi+1}, and H_{pi}/H_{pi-1} in men and women

Vertebra	H_a/H_p		H_m/H_p		H_p/H_{p-1}		H_p/H_{p+1}	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Women								
T4	0.95	0.06	0.89	0.06			0.97	0.06
T5	0.94	0.06	0.89	0.05	1.03	0.06	0.98	0.06
T6	0.93	0.06	0.89	0.05	1.03	0.07	0.98	0.05
T7	0.93	0.06	0.89	0.05	1.02	0.05	0.99	0.05
T8	0.96	0.07	0.90	0.05	1.01	0.05	0.97	0.05
T9	0.98	0.06	0.91	0.05	1.03	0.05	0.95	0.05
T10	0.97	0.07	0.91	0.05	1.06	0.06	0.93	0.05
T11	0.93	0.07	0.90	0.06	1.08	0.06	0.93	0.07
T12	0.92	0.10	0.90	0.08	1.08	0.07	0.96	0.08
L1	0.94	0.09	0.92	0.07	1.05	0.09	0.98	0.07
L2	0.99	0.08	0.93	0.06	1.02	0.07	1.01	0.06
L3	1.02	0.07	0.96	0.05	1.00	0.06	1.05	0.06
L4	1.05	0.09	0.99	0.06	0.95	0.06	1.08	0.10
L5	1.12	0.11	1.04	0.07	0.93	0.08		
Men								
T4	0.95	0.06	0.90	0.05			0.98	0.06
T5	0.95	0.06	0.90	0.05	1.03	0.06	0.98	0.06
T6	0.94	0.06	0.91	0.05	1.02	0.06	0.99	0.05
T7	0.95	0.06	0.91	0.05	1.02	0.06	1.00	0.05
T8	0.97	0.06	0.92	0.05	1.00	0.05	0.99	0.05
T9	1.00	0.07	0.94	0.05	1.01	0.05	0.96	0.05
T10	1.00	0.08	0.94	0.05	1.05	0.06	0.93	0.05
T11	0.94	0.07	0.92	0.05	1.08	0.06	0.93	0.06
T12	0.92	0.07	0.92	0.05	1.08	0.07	0.94	0.07
L1	0.90	0.07	0.91	0.05	1.07	0.08	0.99	0.06
L2	0.95	0.07	0.93	0.05	1.02	0.05	1.02	0.05
L3	0.98	0.07	0.96	0.05	0.99	0.05	1.06	0.06
L4	1.03	0.08	0.99	0.05	0.95	0.05	1.08	0.08
L5	1.11	0.10	1.03	0.07	0.93	0.06		

T10–L5 tended to decrease with advancing age (Table 3). In men, the decrease in vertebral dimension with advancing age was observed at all vertebrae. In each vertebra, the ratio H_a/H_p was greater than H_m/H_p, consistent with the fact that $H_a > H_m$ (Table 4). From T4 to L2, the ratio H_{pi}/H_{pi-1} was consistently greater than 1, and ratio H_{pi}/H_{pi+1} was less than 1; however, the reverse trend was observed for T4 to L2.

Prevalence of vertebral fractures

The prevalence of vertebral fracture was estimated for those aged 50 years and older. Using the reference values for the ratios H_a/H_p, H_m/H_p, H_{pi}/H_{pi-1}, and H_{pi}/H_{pi+1}, the overall prevalence of vertebral fracture in men was 23 % (30/129; 95 % CI 16.6 to 31.3 %), which was lower than that in

Table 5 Prevalence of vertebral fracture in men and women 50 years or above

Age group	Men		Women	
	Cases/*N*	Prevalence (%)	Cases/*N*	Prevalence (%)
50–59	8/66	12.1	38/196	19.4
60–69	9/31	29.0	25/100	25.0
70+	13/32	40.6	42/100	42.0
Total	30/129	23.3	105/396	26.5

Table 6 Classification of vertebral fracture in men and women >50 years

Age group	Men (n=129)		Women (n=396)	
	Cases	Prevalence (%)	Cases	Prevalence (%)
All of vertebral fractures	30	23.3	105	26.5
Classified by type of fracture				
Wedge	11	13.1	58	14.7
Biconcavity	12	9.3	44	11.1
Compression	17	13.2	60	15.2
Two combined fractures				
Wedge+biconcave				
Wedge+compression	20	17.1	96	24.2
Compression+biconcave	20	15.5	72	18.2
Three combined fractures	27	20.1	85	21.5

women 26.5 % (105/396; 95 % CI 22.4 to 31.1 %) (Table 5). The risk of fracture increased with advancing age, such that the gradient was steeper in women than in men. Among those aged 50–59, the prevalence of vertebral fracture in men and women was 12 and 19 %, but among those age 70+years, 41 men and 42 % women had a vertebral fracture.

Table 6 shows the number of fractures classified by type. In men, the commonest fracture was compression, with prevalence rate being 17 %, followed by biconcavity (9.3 %) and wedge (8.5 %). In women, compression and wedge fracture were equivalent with prevalence rate being ~15 %. Most of the fractures occurred on one or two vertebrae. Figure 1 shows that the cases with one or two vertebral fractures accounted for 70 % of all fractures in men. However, in women, the number of cases with one or two fractures accounted for only 57 % of all fractures.

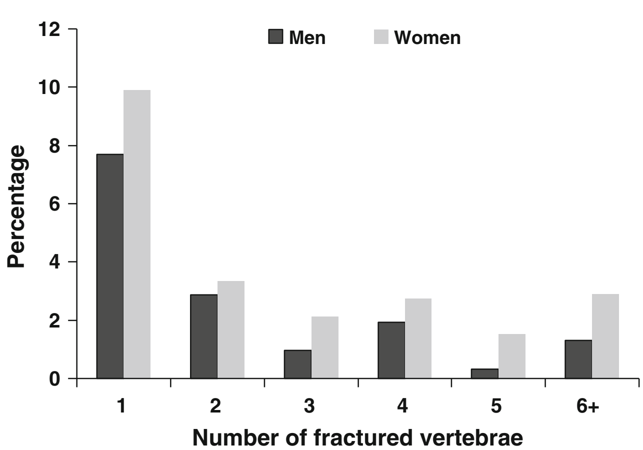

Fig. 1 Percentage of fractures by number of fractured vertebrae

Discussion

Although morphometric vertebral fracture is considered a prima facie of osteoporosis, it is difficult to assess its magnitude in the general population since the disorder has no specific symptom, and there is still no golden standard to define vertebral fractures. Conventional radiography, using either semiquantitative or quantitative morphometry, is widely used to assess vertebral fracture. Semiquantitative method, based on visual assessment of radiographs [18], often overestimates vertebral fractures [19] and is not reproducible enough for clinical and epidemiologic studies. Quantitative morphometric approach is based on a comparison between objective measurements of vertebral heights and standard values, so it is considered to be more reproducible [20]. Using the quantitative method, we have developed reference ranges for vertebral morphometry in Vietnamese men and women, and found that asymptomatic vertebral fracture was present in 23 % of men and 26 % of women.

Changes in vertebral dimensions in the Vietnamese are generally in similar patterns to those in Caucasians [40] and other Asian populations [41]. For example, we found that vertebral heights increase from T4 to L3, with the middle height being lowest and the posterior highest. This distribution is consistent with the fact that wedge and biconcave fractures are observed more often than compressive fracture. Furthermore, we found that the dimensions of L5 were smaller than that of L4 in all heights H_a, H_m, and H_p in both sexes. This observation is consistent with the literature, and it could explain the misdiagnosis of vertebral fracture at L5 in semiquantitative approaches [20]. In this study, we noted some vertebral heights were slightly higher in older individuals, which is not consistent with the majority of vertebrae. This observation may be due to either secular change and/or measurement error since the differences were well within the error of measurement.

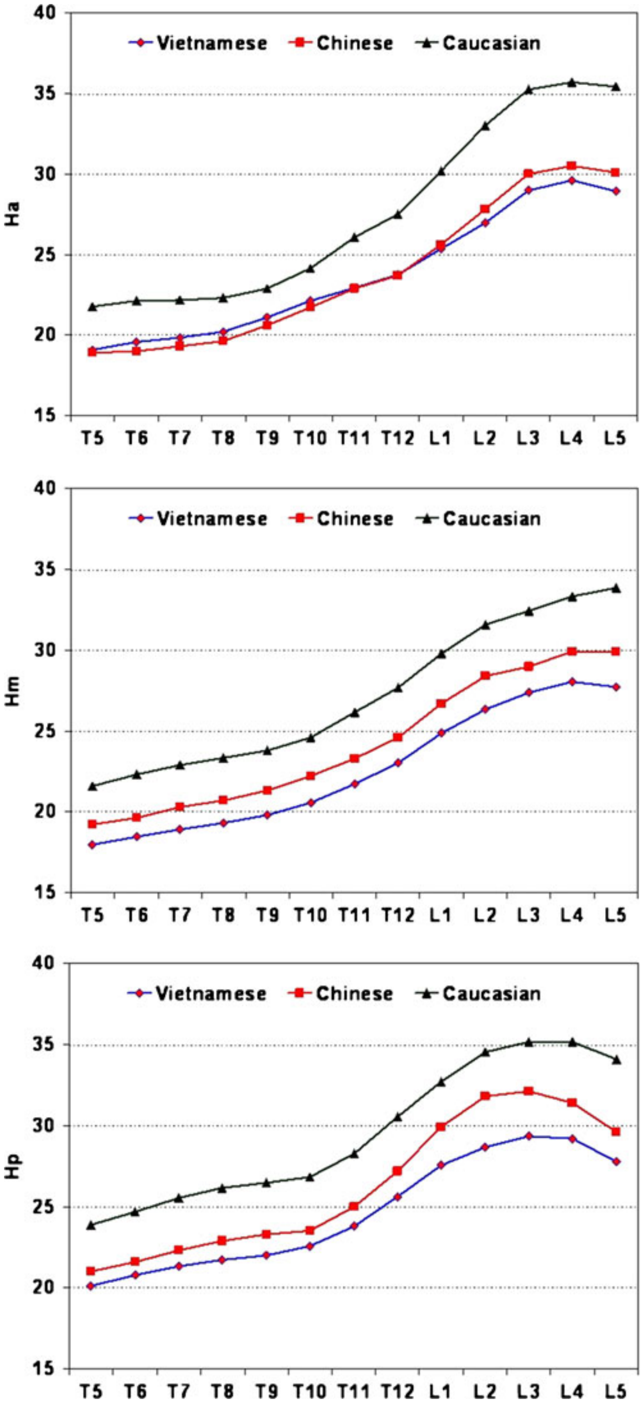

Fig. 2 Comparison of H_a, H_m, and H_p between Vietnamese (the present study), Chinese [42], and Caucasian women [50]

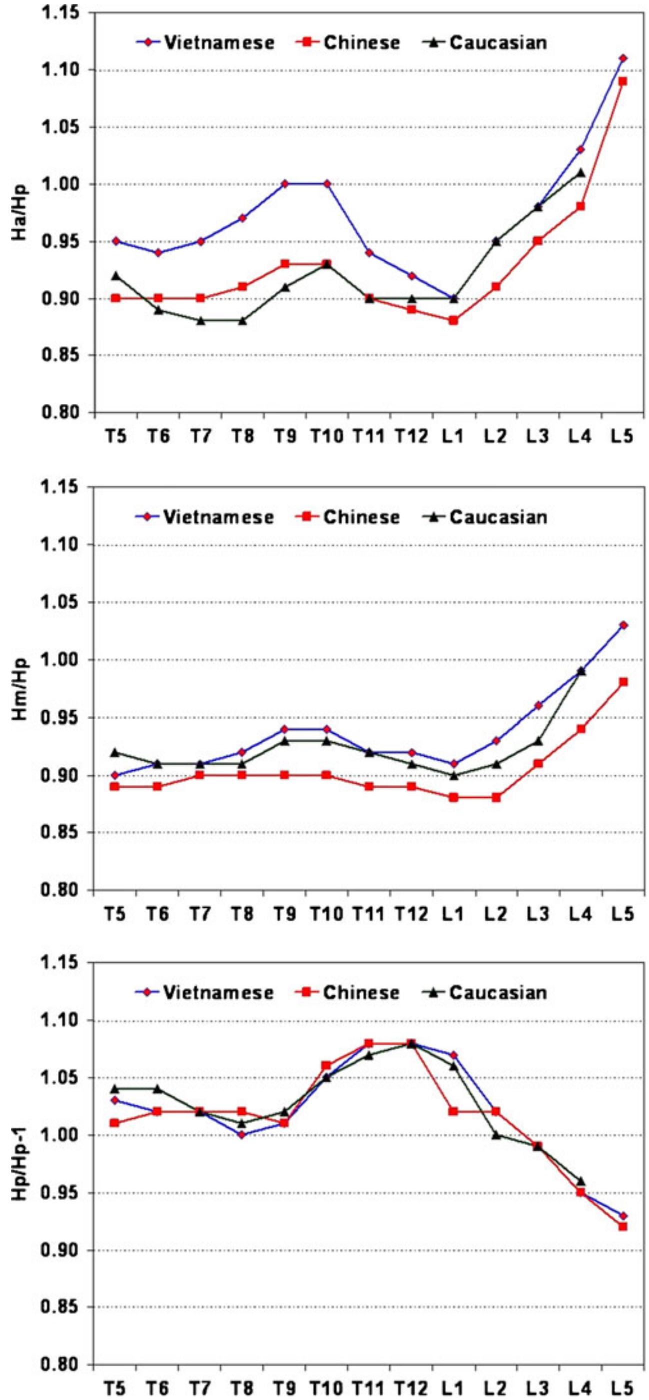

Fig. 3 Comparison of H_a/H_p, H_m/H_p, and H_p/H_{p-1} ratios between Vietnamese (the present study), Chinese [29], and Caucasian men [43]

However, there were considerable discrepancies in the absolute reference values between Vietnamese and other ethnicities. For instance, the anterior H_a, middle H_m, and posterior H_p height in Vietnamese women were comparable to the respective heights in Chinese women [42], but lower than Caucasian women [14] (Fig. 2). In men, the H_a/H_p, H_m/H_p, and H_{pi}/H_{pi-1} ratios in this study were largely comparable to those in Caucasian and Chinese [29] and Caucasian [43] (Fig. 3). These findings suggest that the quantitative definition of vertebral fracture can be based on universal reference data.

The prevalence of vertebral fracture in this population is comparable to that observed in Caucasian populations. In the European Vertebral Osteoporosis Study in 19 European countries with more than 15,000 individuals aged 50–79 years, the prevalence of vertebral fracture ranged between 10 and 22 % in men and from 13 to 28 % in women [21]. The European Prevalence Osteoporosis Study reported a considerable variation in the prevalence rate between countries, with higher prevalence being found in Norway (24 %) and Sweden (28 %) and lower rates in Spain (15 %) [44]. This between-countries variability in the prevalence was also observed in the Latin American Vertebral Osteoporosis Study, where the prevalence of vertebral fracture was 10 % in men [26] and 19 % in women aged 50+years [45].

The variability in vertebral fracture prevalence was also observed in Asian populations. In this study, approximately 23 % of men and 26 % of women aged 50 years and older had at least one vertebral fracture, which is higher than that in the Taiwanese population (also using quantitative method) among whom vertebral fracture was present in 13 % of men and 20 % of women aged 40 years and older [29]. However, a study among women aged 50+ in Thailand found that 36 % had a vertebral fracture [28], while a study in China found an age-related increase in the prevalence of fracture (from 5 % in women aged 50–59 years to 37 % in women aged 80 years) [31]. These differences are likely due to differences in methods of vertebral fracture assessment and demographic characteristics of participants. Furthermore, the intraobserver variability in reading radiographs could also be responsible for the differences in the fracture prevalence [46]. Nevertheless, taken together, these data show that the magnitude of vertebral fracture in Asian populations is highly comparable with that in Caucasian populations.

Morphometric vertebral fracture can be a relevant and serious clinical event. Most randomized controlled trials use morphometric fracture as an outcome for evaluating the antifracture efficacy of an intervention. Individuals with a vertebral fracture have increased risks of reduced pulmonary function, chronic back pain, abdominal discomfort, disability, and loss of independence [47]. More importantly, vertebral fracture is also associated with an increased risk of further fracture and mortality [10]. For example, the 5-year risk of mortality after a vertebral fracture is increased by 20 %, with mortality risk being higher in men than women [48]. Therefore, the fact that almost a quarter of men and women aged 50 years and older have vertebral fracture poses a significant burden to the public health of Asian countries where the populations are rapidly aging.

Although vertebral fracture is increasingly recognized as a serious clinical outcome, it is underdiagnosed. Indeed, it has been estimated that only a third of vertebral fractures come to clinical attention [1], and the majority of individuals with the fracture remain undiagnosed. Even radiologists are reported to have missed vertebral fracture, and the false-negative interpretation of vertebral diagnosis is up to 45 % [19]. The present study's finding suggests that primary care doctors should be vigilant in the reading of radiographs. Assuming that therapy could reduce the risk of vertebral fracture by 50 % (on average), then it could be estimated that the number of individuals that need to be screened [49] to reduce one fracture is around 8.

The present results have to be interpreted within the context of strengths and potential limitations. First, the study used a rigorous random sampling to ensure the representativeness of the general population. Second, the study population is highly homogeneous, which reduces the effects of potential confounders that could compromise the estimates. Third, the quantitative method, which was used in this study, is considered to be highly reliable and accurate for the assessment of vertebral fractures [20]. Nevertheless, the study also has a number of potential weaknesses. The participants in this study were sampled from an urban population; as a result, the study's finding may not be generalizable to the rural populations. Because we excluded individuals with diseases deemed to interfere with bone metabolism, the prevalence of vertebral fracture reported here could be an underestimate of the prevalence in the general population. By employing six-point measures for each vertebra, there may be intra- and interobserver variability in assessment of vertebral dimensions.

Conclusion

In summary, these results provide the first ever reference data for vertebral dimensions for the Vietnamese population. In addition, the study suggests that asymptomatic vertebral fracture is quite common in men and women aged 50 and above and that the prevalence is equivalent to that in Caucasian populations. The results also imply that vertebral fracture and osteoporosis represent a significant public health burden in Vietnam, particularly when the population is rapidly aging.

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Conflicts of interest None.

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