Effect of sex, age, and anthropometric parameters on the size and shape of vertebrae in densitometric morphometry

Results of the EPOLOS study

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KEY WORDS

morphometric densitometry, vertebral size and shape

ABSTRACT

INTRODUCTION Morphometric densitometry (morphometric X-ray absorptiometry – MXA) allows to identify vertebral fractures, based on the objective measurement of vertebral dimensions.

OBJECTIVES The aim of the study was to assess the effect of sex, age, height, and body mass index (BMI) on selected parameters of vertebral size and shape measured by MXA.

PATIENTS AND METHODS A random study sample comprised 829 patients (520 women and 309 men) aged 20 to 79 years, none of whom had been previously treated for osteoporosis. Lateral densitometric scans of the thoracic-lumbar spine (T4–L4) were performed using a fan-beam densitometer. Anterior (Ha), central (Hc), and posterior (Hp) vertebral heights were determined.

RESULTS The analysis included 9632 vertebrae. Higher values of Ha, Hc, and Hp were observed in men ($P < 0.001$). The Ha/Hp ratio from T7 to L3 was lower in men compared with women ($P < 0.05$). The Hc/Hp ratio was lower in T12 to L3 vertebrae in men ($P < 0.05$). Wedging was significantly greater in men in thoracic vertebrae, and significantly lower in L3 and L4 ($P < 0.05$). Concavity was similar in men and women in thoracic vertebrae from T5 to T10. We observed weak and moderate negative correlations between age and vertebral heights, Ha/Hp and Hc/Hp ($P < 0.001$), and a moderate positive correlation between body height and vertebral heights ($P < 0.001$). There were no statistically significant correlations between the body mass index and the remaining variables.

CONCLUSIONS Morphometric parameters of vertebrae vary depending on sex and age, which has to be considered when choosing reference groups. Knowledge about the differences in vertebral size and shape may prevent diagnostic errors and bias.

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INTRODUCTION Identification of osteoporotic fractures is crucial for making therapeutic decisions.[1] Most vertebral fractures are difficult to diagnose.[2] Current methods available for detection of an osteoporotic vertebral fracture include a radiological assessment of spinal radiographs. Use of densitometry for assessing vertebral bodies is now possible because the quality of images has greatly improved. A densitometric image of the lateral spine can be evaluated quantitatively (semiquantitatively) and/or qualitatively.[3,4] A quantitative approach to diagnosing vertebral fractures is called morphometry. It involves the measurement of vertebral heights (anterior, posterior, and central) and the calculation of reduction in their height.[3] Morphometric X-ray absorptiometry (MXA) is a method, in which morphometry is applied to a fan-beam densitometry.[5] It has numerous advantages including time requirement (about 10 seconds), low

TABLE 1 Characteristics of the examined population

	Women	Men	*P*
mean age (years)	67.9 ±8.7	56.49 ±15.21	NS
number of patients	521	309	–
mean height (cm)	161.24 ±6.77	173.96 ±6.65	<0.001
mean weight (kg)	54.75 ±16.55	80.39 ±12.02	<0.001
BMI (kg/m²)	25.17 ±4.39	26.55 ±3.66	<0.001

Data presented as mean ± standard deviation

Abbreviations: BMI – body mass index, NS – nonsignificant

TABLE 2 Anterior, posterior, and central vertebral heights; Ha/Hp ratio and Hc/Hp ratio according to sex

Region	Sex	Ha (mm)	Hp (mm)	Hc (mm)	Ha/Hp	Hc/Hp
T4	M	19.22 ±2.32[a]	20.06 ±2.02[a]	18.98 ±2.35[a]	0.92 ±0.05	0.90 ±0.04
	W	16.94 ±2.11	17.05 ±2.23	16.92 ±1.68	0.92 ±0.06	0.90 ±0.04
T5	M	19.32 ±2.92[a]	20.96 ±3.07[a]	18.97 ±2.51[a]	0.92 ±0.05	0.90 ±0.04
	W	17.34 ±2.4	18.72 ±2.23	16.92 ±1.96	0.92 ±0.06	0.90 ±0.04
T6	M	19.54 ±2.77[a]	21.19 ±2.64[a]	19.14 ±2.30[a]	0.92 ±0.05	0.90 ±0.04
	W	17.96 ±2.47	19.40 ±2.37	17.50 ±2.11	0.92 ±0.06	0.90 ±0.04
T7	M	19.14 ±1.6[a]	21.04 ±1.47[a]	18.76 ±1.38[a]	0.91 ±0.05[a]	0.89 ±0.04
	W	17.86 ±1.42	19.24 ±1.31	17.21 ±1.29	0.92 ±0.05	0.89 ±0.04
T8	M	20.02 ±1.65[a]	21.56 ±1.39[a]	19.24 ±1.29[a]	0.92 ±0.06[a]	0.89 ±0.04
	W	19.7 ±1.57	19.74 ±1.34	17.61 ±1.29	0.94 ±0.06	0.89 ±0.04
T9	M	21.38 ±1.72[a]	22.49 ±1.47[a]	20.15 ±1.41[a]	0.95 ±0.05[c]	0.89 ±0.04
	W	19.86 ±1.72	20.69 ±1.53	19.68 ±1.54	0.96 ±0.05	0.89 ±0.04
T10	M	22.65 ±1.70[a]	24.05 ±1.82[a]	21.33 ±1.66[a]	0.94 ±0.05[a]	0.89 ±0.04
	W	21.11 ±1.9	21.98 ±1.87	19.6 ±1.70	0.96 ±0.06	0.89 ±0.04
T11	M	23.94 ±2.02[a]	25.7 ±1.7[a]	22.60 ±1.63[a]	0.93 ±0.06[b]	0.88 ±0.04
	W	22.41 ±2.32	23.71 ±2.04	20.97 ±2.00	0.94 ±0.06	0.88 ±0.04
T12	M	25.47 ±2.11[a]	27.29 ±1.82[a]	23.95 ±1.80[a]	0.93 ±0.05[a]	0.87 ±0.04[b]
	W	24.26 ±2.04	25.40 ±1.96	22.54 ±2.05	0.95 ±0.04	0.88 ±0.04
L1	M	26.89 ±1.97[a]	28.07 ±1.71[a]	24.94 ±1.79[a]	0.95 ±0.05[b]	0.88 ±0.04[c]
	W	25.73 ±2.30	26.41 ±2.10	23.75 ±2.06	0.97 ±0.06	0.90 ±0.18
L2	M	27.79 ±1.92[a]	28.04 ±1.77[a]	25.22 ±2.00[a]	0.99 ±0.06[a]	0.89 ±0.04[b]
	W	26.89 ±2.20	26.68 ±1.84	24.26 ±2.07	1.00 ±0.06	0.90 ±0.05
L3	M	28.00 ±1.87[a]	27.64 ±1.91[a]	27.02 ±1.88[a]	1.01 ±0.09[a]	0.92 ±0.06[a]
	W	27.17 ±2.10	26.32 ±1.91	26.01 ±1.99	1.03 ±0.07	0.93 ±0.06
L4	M	28.10 ±2.10[a]	26.05 ±2.22[a]	25.06 ±1.95[a]	1.08 ±0.09	0.96 ±0.06
	W	26.97 ±2.17	24.91 ±2.24	24.14 ±2.01	1.08 ±0.08	0.97 ±0.05

Data presented as mean ± standard deviation

a $P<0.001$ **b** $P<0.01$ **c** $P<0.05$

Abbreviations: Ha – anterior vertebral height, Hc – central vertebral height, Hp – posterior vertebral height, M – men, W – women, others – see TABLE 1

radiation, simplicity, and a possibility of combining it with the measurement of bone mineral density.[3,4] On the other hand, spatial resolution for MXA is lower than that for conventional radiography.

The aim of the study was to assess the influence of sex, age, height, and body mass index (BMI) on selected parameters of the size and shape of vertebrae in MXA.

PATIENTS AND METHODS EPOLOS (European Polish Osteoporosis Study) was a multi-center epidemiological study. Its aim was to identify osteoporosis risk factors early enough and introduce effective prophylactic methods to prevent fractures in the Polish population. Invitation forms, explaining the study objectives, were sent to a random sample of men and women, aged 20 to 80 years, derived from the registry of the Department of National Registry, Ministry of the

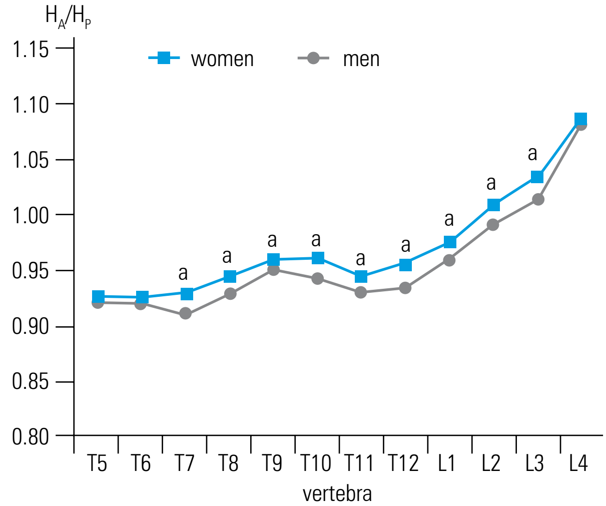

FIGURE 1 Ha/Hp ratio in relation to sex
a $P < 0.05$
Abbreviations: see TABLE 2

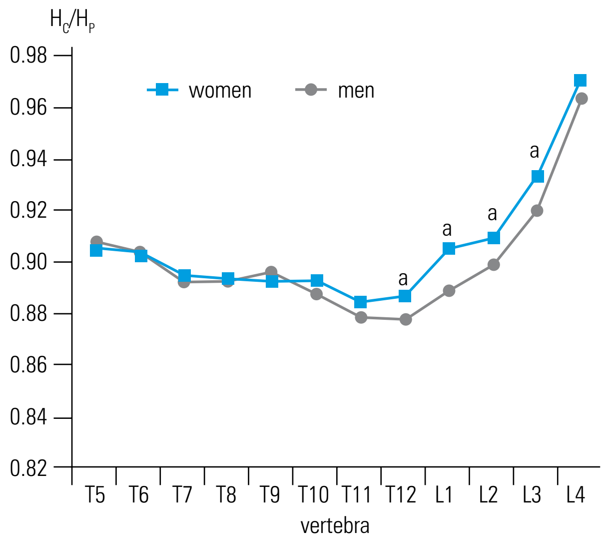

FIGURE 2 Hc/Hp ratio in relation to sex
a $P < 0.05$
Abbreviations: see TABLE 2

Interior and Administration, Poland. Participants for this part of the study were enrolled in the following three Polish cities: Warsaw, Łódź, and Bydgoszcz. The response rate was 12%. A short telephone survey excluded several volunteers. The exclusion criteria were as follow: personal history of osteoporosis, pregnancy, cancer, fracture in the past year, and overweight (>100 kg). The last criterion was related to densitometry equipment requirements. Each patient gave written informed consent. The study was approved by the Ethics Committee of the Children's Memorial Health Institute, Warsaw, Poland.[6,7]

The study involved 829 patients, including 520 women and 309 men, aged 20 to 79 years; none of them had a history of osteoporosis. The characteristics of the study population are presented in TABLE 1. Densitometric signs of osteoporosis were present in 8.5% of women and in 6.2% of men. Previous fragility fractures were observed in 17.2% of patients. Lateral densitometric scans of the thoracic-lumbar spine were acquired using a fan-beam densitometer (Expert-XL, GE, United States). Calibration details have been described elsewhere.[7,8] Vertebral bodies from T4 to L4 vertebrae were demonstrated. Six points were set to calculate the anterior (Ha), central (Hc), and posterior (Hp) height of T4–L4 vertebral bodies. All scans were analyzed by the same operator. The Ha/Hp ratio, Hc/Hp ratio, wedging (Ha – Hp)/Hp and concavity (Hc – Hp)/Hp were calculated.[9]

Statistical analysis was performed using the STATISTICA PL 7.1 software. Variables were presented as mean ± standard deviation (SD). Normality was tested using the Shapiro-Wilk test. Differences between groups (men and women) were analyzed using the Student's t-test for independent samples (for variables with normal distribution) or the U Mann-Whitney test (if the distribution of variables was different from normal). Spearman's rank correlation coefficients were calculated to evaluate dependencies between age, BMI, height, and Ha, Hc, Hp, Ha/Hp and Hc/Hp ratios. $P < 0.05$ was considered statistically significant.

RESULTS The characteristics of the subjects are shown in TABLE 1. As expected, men were significantly taller and heavier and had higher BMI than women ($P < 0.01$). The final analysis comprised 9632 vertebrae; 1148 vertebrae were excluded from the analysis because of poor image quality.

The data concerning the relationship between vertebral heights and sex (mean ± SD) are shown in TABLE 2. In men, statistically significantly higher values of Ha, Hc, and Hp were observed, compared with women ($P < 0.001$). The Ha/Hp ratio from T7 to L3 demonstrated lower values in men compared with women ($P < 0.05$) (FIGURE 1). The Hc/Hp ratio was lower in T12–L3 vertebrae in men ($P < 0.05$) (FIGURE 2). Wedging was significantly greater in men in thoracic vertebrae ($P < 0.005$), and significantly lower in L3 and L4 ($P < 0.01$) (FIGURE 3).

Concavity was similar in men and women when analyzed for thoracic vertebrae from T5 to T10, and was borderline lower in men from T12 to L4. However, the difference was not statistically significant (FIGURE 4).

Moderate but statistically significant negative correlations between age and vertebral heights and Ha/Hp and Hc/Hp were found in women ($P < 0.001$) (TABLE 3, FIGURE 5). Similar but weaker correlations were observed in men (TABLE 3, FIGURE 6). There was a moderate but significant positive correlation between body height and vertebral heights in women ($P < 0.001$) (TABLE 3, FIGURE 7). Similar but weaker correlations were observed in men (TABLE 3, FIGURE 8). Correlations between the Ha/Hp and Hc/Hp ratios and height were not statistically significant. A weak negative correlation between BMI and vertebral heights and Hc/Hp was observed only in women (TABLE 3).

TABLE 3 Correlation coefficients between age, height, and body mass index and vertebral size and shape (continued on the next page)

Vertebra	Variable	Age		Height		BMI	
		W	M	W	M	W	M
T4	Ha	–0.27[a]	–0.27[b]	0.38[a]	0.30[b]	–0.27[a]	–0.27[c]
	Hp	–0.21[a]	–0.21	0.36[a]	0.26[c]	–0.21[b]	–0.21
	Hc	–0.26[a]	–0.30[b]	0.39[a]	0.32[b]	–0.26[a]	–0.30[b]
	Ha/Hp	–0.10	–0.12	0.08	0.18	–0.10	–0.12
	Hc/Hp	–0.12[c]	–0.17	0.08	0.04	–0.12[c]	–0.17
T5	Ha	–0.27[a]	–0.22[b]	0.34[a]	0.35[a]	–0.12[c]	–0.07
	Hp	–0.24[a]	–0.09	0.39[a]	0.41[a]	–0.13[b]	0.00
	Hc	–0.32[a]	–0.20[c]	0.42[a]	0.39[a]	–0.16[b]	–0.04
	Ha/Hp	–0.10[c]	–0.19[c]	0.01	–0.13	–0.03	–0.12
	Hc/Hp	–0.21[a]	–0.19[c]	0.06	–0.15	–0.11[c]	–0.08
T6	Ha	–0.24[a]	–0.19[b]	0.38[a]	0.26[a]	–0.13[b]	0.01
	Hp	–0.19[a]	–0.10	0.39[a]	0.30[a]	–0.06	–0.07
	Hc	–0.28[a]	–0.21[b]	0.43[a]	0.34[a]	–0.14[b]	–0.06
	Ha/Hp	–0.11[c]	–0.14[c]	0.06	0.01	–0.10[c]	0.12[c]
	Hc/Hp	–0.22[a]	–0.16[c]	0.10[c]	0.03	–0.17[b]	–0.04
T7	Ha	–0.25[a]	–0.13[c]	0.43[a]	0.38[a]	–0.20[a]	–0.04
	Hp	–0.20[a]	–0.03	0.46[a]	0.41[a]	–0.11[b]	–0.01
	Hc	–0.29[a]	–0.17[b]	0.46[a]	0.40[a]	–0.20[a]	–0.03
	Ha/Hp	–0.11[c]	–0.15[b]	0.05	0.07	–0.16[b]	–0.05
	Hc/Hp	–0.15[a]	–0.19[a]	0.05	–0.00	–0.13[b]	–0.07
T8	Ha	–0.20[a]	–0.12[b]	0.35[a]	0.41[a]	–0.17[b]	0.01
	Hp	–0.26[a]	–0.05	0.45[a]	0.42[a]	–0.19[a]	–0.05
	Hc	–0.32[a]	–0.21[b]	0.44[a]	0.51[a]	–0.22[a]	–0.09
	Ha/Hp	0.02	–0.15[b]	–0.01	0.11	0.00	0.05
	Hc/Hp	–0.09[c]	–0.20[a]	0.05	0.13[c]	–0.06	–0.08
T9	Ha	–0.21[a]	–0.10	0.39[a]	0.37[a]	–0.20[a]	–0.03
	Hp	–0.27[a]	–0.09	0.43[a]	0.46[a]	–0.20[a]	–0.12[c]
	Hc	–0.32[a]	–0.20[b]	0.43[a]	0.45[a]	–0.23[a]	–0.04
	Ha/Hp	0.01	–0.04	0.05	0.00	–0.06	0.08
	Hc/Hp	–0.15[a]	–0.22[a]	0.09[c]	0.05	–0.11[b]	0.06
T10	Ha	–0.21[a]	–0.11	0.38[a]	0.38[a]	–0.15[b]	–0.02
	Hp	–0.20[a]	–0.09	0.33[a]	0.41[a]	–0.15[b]	–0.00
	Hc	–0.26[a]	–0.21[a]	0.39[a]	0.45[a]	–0.21[a]	0.00
	Ha/Hp	–0.00	–0.02	0.05	–0.05	–0.00	–0.00
	Hc/Hp	–0.10[c]	–0.19[b]	0.08	0.04	–0.10[c]	0.03
T11	Ha	–0.26[a]	–0.10	0.36[a]	0.39[a]	–0.20[a]	–0.05
	Hp	–0.27[a]	–0.05	0.39[a]	0.40[a]	–0.18[a]	–0.01
	Hc	–0.35[a]	–0.17[c]	0.41[a]	0.44[a]	–0.25[a]	–0.04
	Ha/Hp	–0.01	–0.08	–0.01	0.08	–0.04	–0.06
	Hc/Hp	–0.17[b]	–0.19[c]	0.07	0.10	–0.13[b]	–0.08
T12	Ha	–0.29[a]	0.39[a]	0.36[a]	0.42[a]	–0.16[b]	–0.01
	Hp	–0.31[a]	–0.11	0.44[a]	0.48[a]	–0.19[a]	–0.04
	Hc	–0.37[a]	–0.17[c]	0.43[a]	0.49[a]	–0.20[a]	–0.03
	Ha/Hp	–0.01	–0.28[a]	–0.05	0.03	–0.01	0.04
	Hc/Hp	–0.20[a]	0.01	0.10[c]	0.06	–0.06	0.03
L1	Ha	–0.27[a]	–0.15[c]	0.36[a]	0.39[a]	–0.16[b]	0.03
	Hp	–0.30[a]	–0.18[b]	0.48[a]	0.47[a]	–0.17[b]	0.02
	Hc	–0.39[a]	–0.24[a]	0.47[a]	0.50[a]	–0.19[a]	–0.01
	Ha/Hp	–0.02	–0.01	–0.06	0.00	–0.07	0.03
	Hc/Hp	–0.24[a]	–0.14[c]	0.11[b]	0.11[c]	–0.10[b]	–0.06

L2	Ha	–0.30[a]	–0.18[b]	0.43[a]	0.39[a]	–0.22[a]	0.06
	Hp	–0.28[a]	–0.21[b]	0.53[a]	0.45[a]	–0.13[b]	–0.01
	Hc	–0.37[a]	–0.24[a]	0.52[a]	0.45[a]	–0.19[a]	–0.06
	Ha/Hp	–0.06	0.04	–0.02	–0.04	–0.12[b]	0.07
	Hc/Hp	–0.22[a]	–0.05	0.10[c]	0.06	–0.10[c]	–0.06
L3	Ha	–0.23[a]	–0.22[a]	0.42[a]	0.41[a]	–0.13[b]	0.09
	Hp	–0.25[a]	–0.21[b]	0.44[a]	0.42[a]	–0.08[c]	–0.02
	Hc	–0.32[a]	–0.22[b]	0.47[a]	0.43[a]	–0.17[b]	–0.06
	Ha/Hp	0.00	–0.01	–0.01	–0.01	–0.05	0.14[c]
	Hc/Hp	–0.10[c]	–0.06	0.01	0.05	–0.11[b]	–0.04
L4	Ha	–0.25[a]	–0.18[b]	0.41[a]	0.42[a]	–0.10[c]	0.03
	Hp	–0.17[b]	–0.24[a]	0.34[a]	0.34[a]	–0.03	0.02
	Hc	–0.24[a]	–0.20[a]	0.40[a]	0.35[a]	–0.05	–0.02
	Ha/Hp	–0.01	0.06	–0.02	–0.00	–0.05	0.01
	Hc/Hp	–0.04	0.06	–0.01	–0.02	–0.01	–0.05

a $P < 0.001$ **b** $P < 0.01$ **c** $P < 0.05$

Abbreviations: see **TABLE 2**

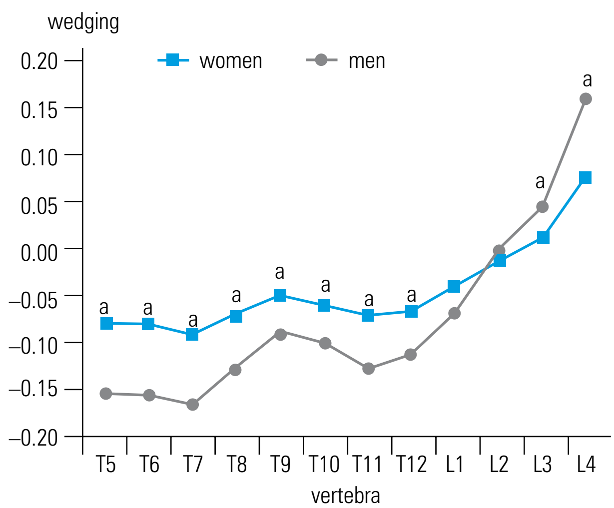

FIGURE 3 Wedging in relation to sex
a $P < 0.05$

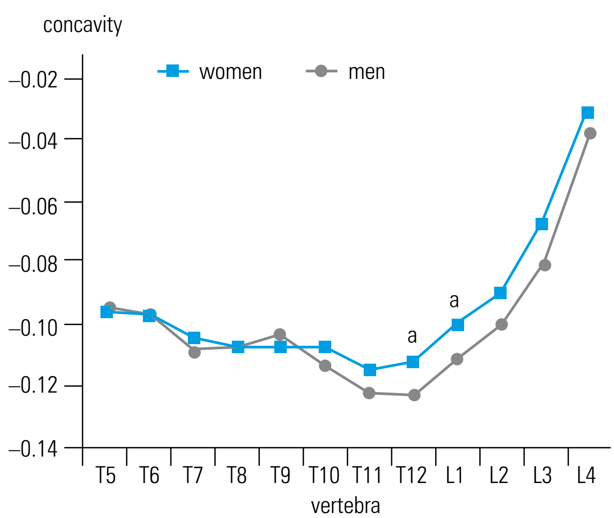

FIGURE 4 Concavity in relation to sex
a $P < 0.05$

DISCUSSION Our study has been the first to evaluate the effect of sex, age, height, and BMI on vertebral dimensions obtained by MXA in the Polish population. Indices of vertebral shape and size assessed by morphometry are used to define vertebral fractures. It has been suggested that the reference data obtained for morphometric radiography are not appropriate for MXA,[10,11] probably because of a greater variability in point placement for MXA.[10] Vertebral height ratios vary between populations.[10-13] These variations may result from the real differences[12,13] or methodological discrepancies.[13] The reference data for MXA vertebral dimensions had been published previously,[10-12] and most of them concerned women.[10,11] Our results are in line with those of Rea et al.,[11] probably due to a similar height of the examined women. Argentinian women seemed to be shorter; however, the scans were obtained using different equipment (Hologic). Unlike the study of the above-cited authors,[11] our data were not trimmed. Only one study regarding male-specific MXA reference ranges has been published;[10] however, the data about vertebral dimensions were shown as mean vertebral wedge, biconcave, and compression deformity. We additionally analyzed wedging and concavity, because they are independent of body height.[9] We observed higher wedging, but not concavity, in men. Our results concerning wedging are in agreement with those of Ferrar et al.,[10] but in contrast to that study, we observed similar concavity in men and women. We observed that the change of vertebral shape was similar in men and women; the vertebral body was anteriorly wedged from T5 to L1, nonwedged at L2, and posteriorly wedged at L4 to L5.

We demonstrated higher values of Ha, Hc, and Hp, but lower Ha/Hc ratio in men. The same tendency was observed by O'Neill et al.[13] and Cheng et al.,[14] although these investigators obtained their results using morphometric radiography.

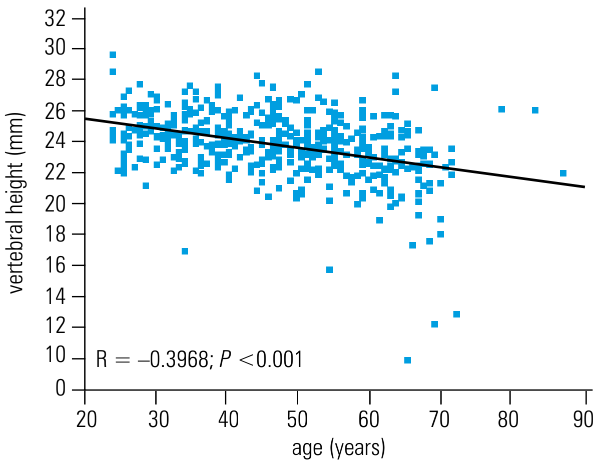

FIGURE 5 Correlation between age and central vertebral height in women in the case of L1

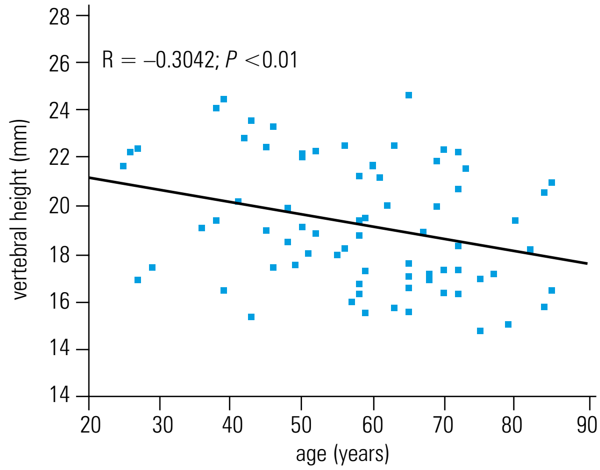

FIGURE 6 Correlation between age and central vertebral height in men in the case of T8

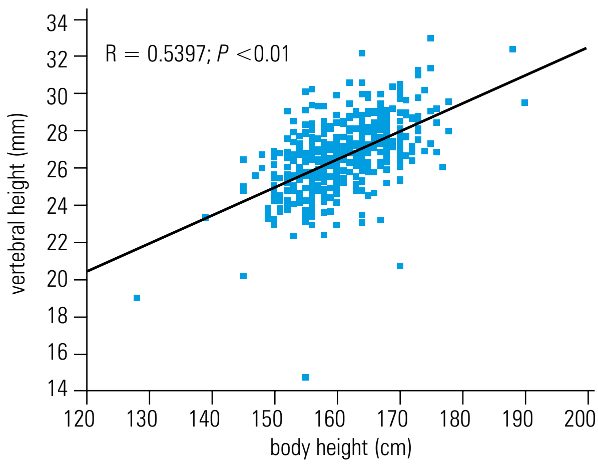

FIGURE 7 Correlation between body height and posterior vertebral height in women in the case of L2

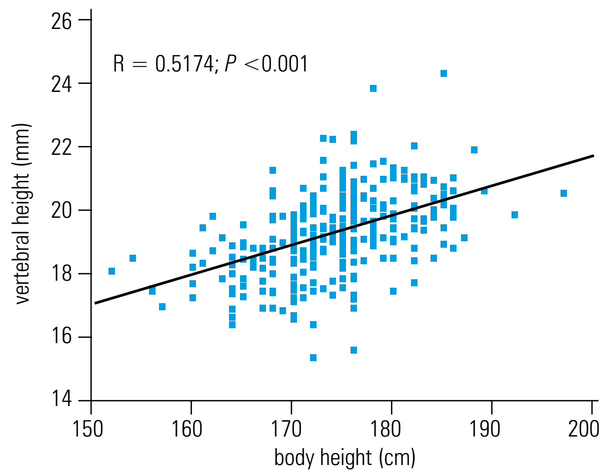

FIGURE 8 Correlation between body height and central vertebral height in men in the case of T8

We observed a moderate decrease in vertebral heights with increasing age. A similar tendency was observed by other authors.[9,15,16] The effect of age could in fact result from aging or could be explained by a cohort effect of environmental factors such as physical activity or diet. Age-related changes in vertebral height may be caused by osteoporosis[15] or may reflect degenerative changes induced by biomechanic load acting on the spine.[16]

Recently, the role of vertebral size has been increasingly recognized. It has been reported by a number of investigators that bone strength is positively correlated with bone size.[17,18] It has been shown that patients with vertebral fractures have smaller nonfractured vertebrae than patients without fractures.[19] Small vertebral size should be considered as a potential independent risk factor of vertebral fractures.

Our results have clinical implications, because the understanding of sex- and age-related differences is important when designing reference groups and may prevent diagnostic errors and bias.

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ARTYKUŁ ORYGINALNY

Wpływ płci, wieku i parametrów antropometrycznych na wielkość i kształt kręgów w badaniu morfometrii densytometrycznej

Wyniki badania EPOLOS

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SŁOWA KLUCZOWE

morfometria densytometryczna, wielkość i kształt kręgów

STRESZCZENIE

WPROWADZENIE Morfometria densytometryczna (*morphometric X-ray absorptiometry* – MXA) pozwala na zidentyfikowanie złamań kręgowych na podstawie obiektywnych pomiarów wymiarów trzonów kręgowych.

CELE Celem badania było określenie wpływu płci, wieku, wzrostu i wskaźnika masy ciała (*body mass index* – BMI) na wybrane parametry wielkości i kształtu kręgów w badaniu MXA.

PACJENCI I METODY Do badania włączono wybranych losowo 829 pacjentów (520 kobiet i 309 mężczyzn) w wieku 20–79 lat, nieleczonych wcześniej z powodu osteoporozy. Boczne skany densytometryczne kręgosłupa piersiowo-lędźwiowego (T4–L4) wykonano densytometrem Expert-XL. Wyznaczano przednią (*anterior height* – Ha), środkową (*central height* – Hc) i tylną (*posterior height* – Hp) wysokość trzonów kręgowych.

WYNIKI Analizie poddano 9632 kręgi. U mężczyzn stwierdzano większe wartości Ha, Hc i Hp ($P < 0{,}001$). Wartość ilorazu Ha/Hp w kręgach T7–L3 była większa u mężczyzn niż u kobiet ($P < 0{,}05$). Iloraz Hc/Hp był mniejszy w kręgach T12–L3 u mężczyzn ($P < 0{,}05$). Współczynnik klinowatości był znacząco większy u mężczyzn niż u kobiet w kręgach piersiowych, a zmniejszał się w kręgach L3 i L4 ($P < 0{,}05$). Współczynnik zmiażdżenia w kręgach piersiowych T5–T10 nie różnił sie u kobiet i mężczyzn. Słabe lub umiarkowanie silne ujemne korelacje stwierdzono między wiekiem i wysokością kręgów, Ha/Hp oraz Hc/Hp ($P < 0{,}001$) zarówno u mężczyzn jak i kobiet. Dodatnie korelacje o umiarkowanej sile wykazano między wzrostem a wysokościami kręgów ($P < 0{,}001$). Nie stwierdzono istotnych statystycznie zależności między pozostałymi badanymi zmiennymi a wskaźnikiem BMI.

WNIOSKI Parametry morfometryczne kręgów różnią się w zależności od płci i wieku, co ma znaczenie przy doborze grup referencyjnych. Wiedza na temat różnic w kształcie kręgów może zapobiec błędom diagnostycznym.

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