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Original Article

Comparison of Best Regions for BMD Measurement Regarding the Age, Weight and Height of Postmenopausal Women

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Osteoporosis is a major public health problem. Menopause provokes a decrease in bone mineral density (BMD) that causes postmenopausal osteoporosis. This study aimed to compare different regions for BMD measurement in postmenopausal women, with regarding to the effect of age, weight and height. 313 osteoporotic menopaused women were classified in 1 of 3 categories on the basis of their age (50-55, 56-60, and 61-65 years old), weight (under 51, 51-60, 61-70, 71-80, and more than 80 Kg), height (till 145, 146-150, 151-155, 156-160, and higher than 160 cm). BMD was evaluated based on T-score and percentage of BMD. Data are presented on those regions of the femur (right femoral, left femoral, right total neck, and left total) neck and lumbar (L1–L4) spine. In comparison between lumbar spine and femur, the lumbar spine region had more significant effects on BMD measurement in menopaused old women regarding to the age, weight and height division. Also, the neck region of the femur region was more important than the total neck region. In the neck region, neck left T-score was more efficient than neck right. These were stable in all age, weight, and height classifications after menopause. So, age, weight, and height of women older than 50 years that are menopaused, are not effecting on calcification of important BMD measurement regions.

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Osteoporosis is a multifactorial disease and a major public health problem with a great socioeconomic impact in terms of morbidity, disability and mortality (1). This disease is the result of disordered bone remodeling (2) with increased incidence of fractures upon bone mineral density decline (3).

Peak bone mass is reached in the mid-twenties for spine and hip (4) and loss of bone mass is part of the normal ageing process (5, 6). Osteoporosis associated fractures and its financial and personal costs are common in the elderly, mainly in postmenopausal women (7). In older age groups, 1 out of 3 women and 1 out of 6 men will develop a hip fracture (8). It was estimated that hip fractures will more than double by the year 2050 in the United States and in Asia with a tenfold increase in osteoporotic fractures (9). The ovarian function and estrogen deficiency decline is more important than ageing in bone mineral density (BMD) loss (10-12), causing increased skeletal resorption and relatively decreased bone formation (13).

Relatively, menopause provokes a decrease in BMD (14-16), that ends up to postmenopausal osteoporosis (PMOP). In both sexes, at around the age of 40, 0.3-0.5% of cortical bone is lost per year, but after menopause women have a superimposed rate of cortical bone loss of 2-3% per year for 8-10 years (17). Because median age at the menopause is currently around 50 years in western countries (18), osteoporosis has mostly been regarded as a disease mainly affecting women over the age of 50 (19).

Over the last few decades, there has been much discussion about the causes and nature of osteoporosis. Osteoporosis risk factors include gender (20), ethnicity (21, 22) and genetics (23), smoking (24), dietary intake (25) and exercise (26), advancing age, premature menopause, body stature, alcohol abuse, and low calcium intake (27). Usually obesity is a protective factor against osteoporosis in men and women (28) and is associated with BMD increase (29, 30),while low weight had been also associated with fractures (31). Adiposity has a strong association with estrogen levels, that is a major determinant of trabecular microstructure in the elderly (32). Reduction of physical activity that is common in obese people would reduce their bone quality.

Evidence from many countries reveals that the prevalence of osteoporosis is increasing with an increasing incidence of hip and vertebral fractures (17). The commonly accepted osteoporotic fractures are those of vertebral crush, femoral neck or intertrochanteric, and colles' ones (13).

Finally, considering previous studies, the present study was designed to compare the evaluate the effects of age, weight and height on BMD values of different regions in postmenopausal women.

Materials & methods

Subjects

This study was performed on 313 osteoporotic menopaused women. Menopause was defined clinically as the absence of menstrual cycles for at least 12 months. Based on both Z-score and T-score of BMD, we elected OP patients. Patients were older than 50 years when admitted to the outpatient clinic. Patients were classified in 1 of 3 categories on the basis of their age (50-55, 56-60, and 61-65 years old), weight (under 51, 51-60, 61-70, 71-80, and more than 80 kg), height (till 145, 146-150, 151-155, 156-160, and more than 160 cm). Data related to patients are illustrated in Table 1.

Bone mineral density, height and weigth measurements

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Dual-energy X-ray absorptiometry (DXA) is the reference standard for measuring BMD at the lumbar spine and proximal femur. In postmenopausal women, BMD measurements were interpreted using the T-score, computed as the difference between observed BMD and same-site BMD in young healthy women, they were expressed in standard deviation (SD) units. The world health organization defines osteoporosis as a T-score≤−2.5 (33). For more and better comparing we also measured Z-score, computed as the difference between observed BMD and same-site BMD in same age healthy women. BMD was measured for the femur (right femoral neck, left femoral neck, and right total neck, left total neck) and lumbar (L1–L4) spine.

Height was measured using a wall-mounted headboard. Weight was measured with a mechanic weight scale.

Statistical analyzes

Statistical analyzes were performed with SPSS software for Windows (Statistical Product and Service Solutions, version 11.5, SSPS Inc., Chicago, IL, USA). The data are expressed as the mean± SEM for each experimental group and tested with analysis of variance (one-way ANOVA) followed by Tukey's or Dunnett's posthoc tests of multiple comparisons. Values with $P \leq 0.05$ were considered as significant.

Results

Effect of age on BMD

BMD values related to age are illustrated in Table 2. There were significant differences in T-score values of left femoral neck [$F(2, 313) = 3.7$, $P \leq 0.05$], right femoral neck [$F(2, 313) = 3.8$, $P \leq 0.05$], left total neck [$F(2, 313) = 3.4$, $P \leq 0.05$], right total neck [$F(2, 313) = 4.5$, $P \leq 0.05$]. Also, significant difference in Z-score value of L1-L4 [$F(2, 313) = 15.7$, $P \leq 0.001$] was observed. There were not significant differences in T-score values of L1-L4, Z-score values of left femoral neck, right femoral neck, left total neck, and rigth total neck.

In comparing the region of BMD measurement, there were significant differences in the age group of 50-55 years [$F(4, 410) = 74.3$, $P \leq 0.001$], the group of 56-60 years [$F(4, 645) = 73.3$, $P \leq 0.001$], and in

Table 1. Comparison of the categories for BMD measurement

		Number	Height	Weight
Age (Years)	50-55	82	154.15 ±0.62	65.66 ±1.35
	56-60	129	154.29 ±0.62	66.28 ±1
	61-65	102	153.69 ±0.51	66.48 ±1.23
		Number	**Age**	**Height**
Weight (kg)	under 51	23	56.97±0.77	150.78±1.03
	51-60	90	57.69±0.43	152.24±0.82
	61-70	100	57.63±0.39	155.12±0.53
	71-80	61	58.08±0.48	155.03±0.57
	more than 80	39	57.56±0.67	155.9±0.75
		Number	**Age**	**Weight**
Height (cm)	till 145	20	57.55±0.91	59.4±2.46
	146-150	77	58.09±0.42	63.33±1.5
	151-155	99	57.65±0.41	65.76±1.09
	156-160	88	57.37±0.43	70.36±1.39
	more than 160	29	57.7±0.65	67.17±1.7

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the group of 61-65 years [F (4, 510)= 51.8, P≤ 0.001].

Data related to the percentage of BMD values of different regions in different age groups are illustrated in figure 1. In comparing the region of BMD measurement, there were significant differences in the age group of 50-55 years [F (4, 410)= 38, P≤ 0.001], the group of 56-60 years [F (4, 645)= 43.6, P≤ 0.001], and in the group of 61-65 years [F (4, 510)= 29, P≤0.001].

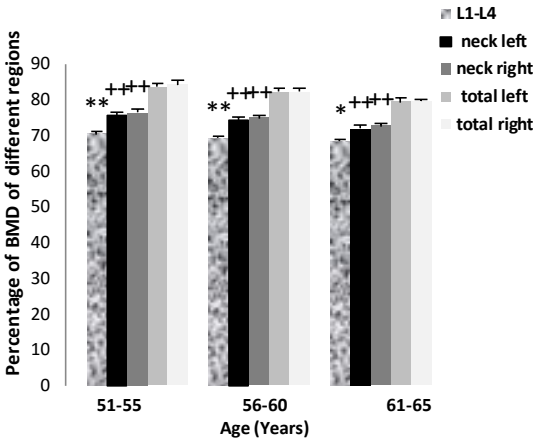

Figure 1. Percentage of BMD of different regions according to age. * P≤0.05, ** P≤0.001 with other regions, ++ P≤0.001 with both of T-score total left and T-score total right.

Effect of body weight on BMD

Data related to body weight are illustrated in Table 3. There were significant differences in T-score values of femoral left neck [F (4, 313)= 2.9, P≤ 0.05], femoral right neck [F (4, 313)= 4, P≤ 0.005], left total neck [F (4, 313)= 2.7, P≤ 0.05]. Also, significant differences in Z-score values of femoral right neck [F (4, 313)= 2.8, P≤ 0.05], right total neck [F (4, 313)= 3.2, P≤ 0.05] were observed. There were not significant differences T-score values of L1-L4, right total neck, as well as Z-score values of L1-L4, left total neck, and femoral left neck.

In comparing the region of BMD measurement, there were significant differences in the weigth group under 51 Kg [F (4, 115)= 13.6, P≤ 0.001], the group of 51-60 Kg [F (4, 450)= 44.1, P≤ 0.001], the group of 61-70 Kg [F (4, 500)= 67.7, P≤0.001], the group of 71-80 Kg [F (4, 305)= 56.1, P≤ 0.001], and finally the group of more than 80 Kg [F (4, 195)= 35.5, P≤ 0.001].

Data related to the percentage of BMD values of different regions in different weigth groups are illustrated in figure 2. The comparison of different regions of BMD measurement, showed that there were significant differences regarding the weight. For the weight group of under 51 Kg [F (4, 115) =4.4, P≤ 0.005], for the group of 51-60 Kg [F (4, 450)= 23.6, P≤ 0.001], for the group of 61-70 Kg [F (4, 500) = 31.9, P≤0.001], for the group of 71-80 Kg [F (4, 305) = 51.7, P≤0.001], and finally for the

Table 2. The effects of age on BMD measurement parameters

		T-score L1-L4	T-score neck left	T-score neck right	T-score total left	T-score total right
Age (Years)	50-55	2.9±0.06++	1.8±0.07*##	1.75±0.07*##	1.32±0.09*	1.31±0.08*
	56-60	2.98±0.06++	1.87±0.07##	1.82±0.07##	1.42±0.08	1.45±0.08
	61-65	3.07±0.07++	2.09±0.07#	2.03±0.07#	1.63±0.08	1.71±0.1
		Z-score L1-L4	Z-score neck left	Z-score neck right	Z-score total left	Z-score total right
	50-55	2.28±0.07**	0.95±0.07	0.84±0.07	0.76±0.08	0.77±0.07
	56-60	2.07±0.05**	0.81±0.06	0.78±0.06	0.69±0.07	0.66±0.08
	61-65	1.76±0.07	0.8±0.06	0.74±0.07	0.63±0.07	0.62±0.08

Values represent the mean ± SEM in 313 OP patients. About different ages, * p≤0.05 and ** p≤0.005 with age 60-65. About different regions of BMD measurement, ++ p≤0.001 with other regions, # p≤0.05, ## p≤0.005 with both of T-score total left and T-score total right.

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group of more than 80 Kg [F (4, 195) = 24.2, P≤ 0.001].

Effect of height on BMD

Data related to height are illustrated in Table 4. There were significant differences in T-score values of L1-L4 [F (4, 313)= 7.5, P≤ 0.001], femoral left neck [F (4,313) = 8.5, P≤ 0.001], femoral right neck [F (4, 313)= 7.4, P≤ 0.001], left total neck [F (4, 313)= 9.5, P≤ 0.001], right total neck [F (4, 313)= 7.2, P≤0.001]. Also, significant difference in Z-score value of L1-L4 [F (4, 313)= 7.1, P≤ 0.001] was observed. . There were not significant differences in Z-score values of left femoral neck, right femoral neck, left total neck, and rigth total neck.

In comparing the region of BMD measurement, there were significant differences in the heigth group of till 145 cm [F (4, 100)= 10.6, p ≤0.001], the group of 146-150 cm [F (4, 385)= 54.8, P≤ 0.001], the group of 151-155 cm [F (4, 495) = 60.7, P≤ 0.001], the group of 156-160 cm [F (4, 440)= 55, P≤0.001], and finally in the group of more than 160 cm [F (4, 145)= 15.2, P≤ 0.001]. Data related to the percentage of BMD values of different regions in different height groups are illustrated in figure 3. The comparison of different regions of BMD measurement showed that there were significant differences regarding the height. For the group of height till 145 cm [F (4, 100)= 4.4, P≤ 0.005], for the group of 146-150 cm [F (4, 385)= 25.6, P≤0.001], for the group of 151-155 cm [F (4, 495)= 36.8, P≤0.001], for the group of 156-160 cm

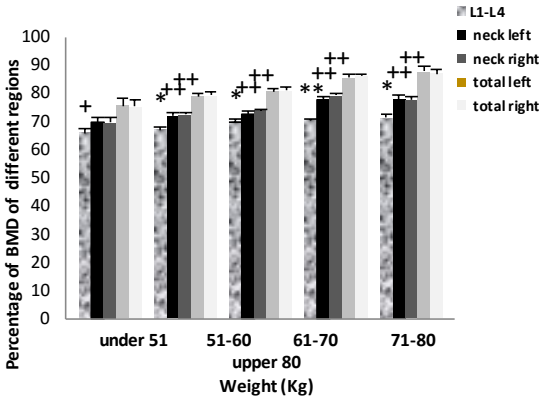

Figure 2. Percentage of BMD of different regions according to weight. * P≤0.05, ** P≤0.001 with other regions, + P≤0.05, ++ P≤0.005 with both of T-score total left and T-score total right.

Table 3. The effects of weight on BMD measurement parameters

		T-scoreL1-L4	T-score neck left	T-score neck right	T-score total left	T-score total right
Weight (kg)	under 51	3.37±0.15&&	2.27±0.15	2.28±0.13	1.92±0.18	1.99±0.18
	51-60	3.21±0.06&&	2.11±0.08%	2±0.09	1.68±0.1	1.74±0.12
	61-70	2.92±0.06*&&	2.02±0.06%%	1.95±0.07%%	1.54±0.08	1.53±0.08
	71-80	2.77±0.11**&&	1.6±0.1**##%%	1.53±0.08**##%	1.15±0.08**#	1.14±0.08**
	more than 80	2.76±0.09**&&	1.64±0.1**#%%	1.65±0.1+%	0.98±0.13**##	1.15±0.16**
		Z-score L1-L4	**Z-score neck left**	**Z-score neck right**	**Z-score total left**	**Z-score total right**
	under 51	1.83±0.16	0.72±0.15	0.74±0.13	0.82±0.17	0.79±0.17
	51-60	1.94±0.07	0.85±0.08	0.75±0.08	0.7±0.09	0.65±0.09
	61-70	1.89±0.07	0.9±0.06	0.84±0.07	0.76±0.08	0.71±0.08
	71-80	2.18±0.06	0.71±0.07	0.62±0.07	0.54±0.08	0.5±0.08
	more than 80	2.45±0.12**##	0.97±0.1	0.96±0.11	0.66±0.12	0.83±0.14

Values represent the mean ± SEM in 313 OP patients. About different ages, * p≤0.05 and ** p≤0.005 with both of weight under 51 and 51-60, # p≤0.05 and ## p≤0.005 with weight 61-70, + p≤0.05 with weight under 51. About different regions of BMD measurement, && p≤0.001 with other regions, % p≤0.05, %% p≤0.005 with both of T-score total left and T-score total right.

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[F (4, 440)= 41, P≤ 0.001], and finally for the group of higher than 160 cm [F (4, 145)= 6.1, P≤0.001].

Discussion

In this study we compared the best regions for BMD measurement regarding to the effect of age, weight and height in postmenopausal osteoporotic women older than 50 years. We used both T- and Z-score for comparing, femoral (right, left, right total, and left total) neck and lumbar (L1–L4) spine regions. Lumbar spine and femoral neck BMD are important, because these two regions are major bone fracture sites (34).

According to our results, Z-score was not effective for PMOP; which was in agreement with other studies. Also, the present study approved that OP may increase with advancing age, decreasing weight and height after menopause. In this regard, other studies indicated that age peak bone mass was reached in the mid-twenties for spine and hip (4) and loss of bone mass was part of the normal ageing process (5, 6). The ovarian function and estrogen deficiency decline cause an increase in skeletal resorption and relatively decrease of bone formation

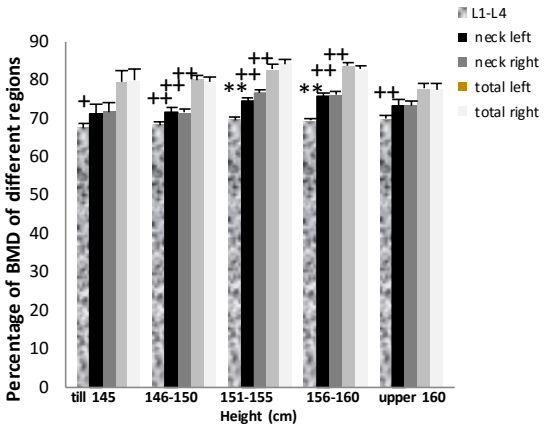

Figure 3. Percentage of BMD of different regions according to height. ** P≤0.005 with other regions, + P≤0.05, ++ P≤0.005 with both of T-score total left and T-score total right.

(13). So, menopause provokes a decrease in BMD (14-16).

In the present study the comparison of lumbar and femoral regions indicate that the lumbar region was more important for BMD measurement in menopaused old women. This result was observed in all age, weight and height subgroupss. Also, this study showed that femoral region of the neck was more important than the total region; and in the neck, the left neck T-score evaluation was more efficient than the right neck. Evidence from many countries

Table 4. The effects of height on BMD measurement parameters

		T-scoreL1-L4	T-score neck left	T-score neck right	T-score total left	T-score total right
Height (cm)	till 145	3.21±0.1++	2.18±0.21	2.11±0.19	1.61±0.23	1.62±0.24
	146-150	3.09±0.07++	2.11±0.08%%	2.12±0.08%%	1.59±0.09	1.62±0.1
	151-155	2.96±0.07++	1.89±0.07%%	1.75±0.07*%	1.36±0.09	1.34±0.11
	156-160	2.88±0.09++	1.78±0.08*%	1.76±0.07*&	1.32±0.08	1.45±0.09
	more than 160	2.98±0.11++	1.94±0.14	1.78±0.19	1.79±0.11	1.79±0.11
		Z-score L1-L4	**Z-score neck left**	**Z-score neck right**	**Z-score total left**	**Z-score total right**
	till 145	1.98±0.13	0.91±0.21	0.84±0.19	0.65±0.22	0.61±0.23
	146-150	1.99±0.07	0.91±0.08	0.93±0.08	0.75±0.09	0.68±0.1
	151-155	1.95±0.07	0.75±0.07	0.62±0.07*	0.57±0.09#	0.49±0.08##
	156-160	2.14±0.07	0.82±0.06	0.78±0.06	0.66±0.07	0.76±0.08
	more than 160	2.04±0.11	1.01±0.13	0.92±0.1	1.03±0.1	1.05±0.1

Values represent the mean ± SEM in 313 OP patients. About different ages, * p≤0.05 with height 146-150, # p≤0.05 and ## p≤0.005 with height upper 160. About different regions of BMD measurement, ++ p≤0.005 with other regions, % p≤0.05, %% p≤0.005 with both of T-score total left and T-score total right, & p≤0.005 with T-score total left.

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reveals that the prevalence of osteoporosis is increasing with an increasing incidence of hip and vertebral fractures (17). The decrease of bone density in the vertebrae starts even before the menopause (35). The lumbar bone loss starts in the perimenopausal period and probably before the definitive cessation of the menses (15). Also, it seems that menopause at an age less than 45 years; negatively affect only vertebral BMD, while it does not affect total hip or femoral neck BMD (36).

Menopause-related BMD decrement is very evident during the first year after menopause, with more evidence in spine than forearm (37). Ten years later, yearly diminution of BMD at spine is still more than forearm, and 60% of the total spinal bone loss in women during their adult life will be lost at this time (37). Also, it was shown that in comparison to femoral sites, lumbar spine bone loss seems to continue until later years after menopause (38). A few studies found different responses to menopause between femoral, vertebral and forearm bone (39, 40). Regarding the weight and height, it was demonstrated that in postmenopausal women low weight and short height correlate better with osteoporosis, than low BMI (41, 42).

According to the international osteoporosis foundation, for preference to a single site, the femoral neck or total hip should be chosen (43, 44). While, based on the present findings, for menopause women the best result for diagnosis of PMOP was associated with lumbar (L1-L4), followed by femoral neck and especially left neck. These were stable in all age, weight, and height classifications after menopause. So, we concluded that age, weight, and height of women older than 50 years that are menopaused, are not effecting on calcification of important BMD measurement regions.

Conflict of interest

The authors declared no conflict of interest.

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