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ORIGINAL ARTICLE

Relationship between arm span and height in postmenopausal osteoporotic women

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Abstract Osteoporosis is a progressive systemic skeletal disease characterized by low bone density and microarchitectural deterioration of the bone. A minimum 3-cm difference between arm span and height makes up one of the criteria for suspecting osteoporosis. Therefore, it is easy to determine osteoporotic women by measuring the proportion of height to the arm span. The purposes of this study are to assess the relationship between arm span and height and to compare them in postmenopausal and young healthy women. This was a randomized-controlled, prospective study. There were two groups in this study. Group I included 70 postmenopausal osteoporotic women and group II had 70 healthy young women. Height, weight and arm span of the individuals were measured in all subjects. Bone mineral density and radiological examination of spine were also evaluated. Mean age of postmenopausal women was 64.4 ± 8.6 years and it was 27.3 ± 3.5 years in young healthy women. Mean height was 152 ± 5.1 and 161.5 ± 5.9 cm in group I and II, respectively. Mean arm span length was 159.6 ± 6.3 cm in postmenopausal women and 163.5 ± 6 cm in young healthy women. Mean arm span-height difference was significantly higher in postmenopausal women when compared to healthy young women (7.7 ± 3.6 and 2 ± 2.9 cm, respectively, $P < 0.001$). We suggest that arm span measurements can be used in the estimation of youth height and age-related loss in stature in postmenopausal women.

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Introduction

Osteoporosis is a progressive systemic skeletal disease characterized by low bone density and microarchitectural deterioration of the bone [1]. In the aging population of the world, osteoporosis has been increasing in prevalence and it remains largely undiagnosed. This may be due to the fact that osteoporosis is clinically silent until a fracture occurs. The most common type of osteoporotic fracture is vertebral fracture, which causes vertebral deformities. However, only one-third of the vertebral fractures give rise to symptoms [2,3]. Vertebral deformities due to vertebral fractures are associated with increased morbidity and symptoms such as loss of height, kyphosis, back pain, functional impairment, depression and reduced survival rates [4]. Patients who have one osteoporotic fracture are at increased risk for having another osteoporotic fracture. Identification of these asymptomatic individuals is important.

Marcus Vitruvius Pollio (born ca. 80/70 BC; died ca. 25 BC) was a Roman writer, architect and engineer, who lived in the first century BC [5]. When he was working on the Roman architecture, he realized the proportions of the greatest work of art, —the human body. This led Vitruvius to the defining of his Vitruvian Man, as drawn magnificently by Leonardo da Vinci—the human body inscribed in the circle and the square. For the first time, Vitruvius indicated the relation between arm span and height. It has recently been demonstrated that arm span and height are approximately equal in young adults. In the presence of vertebral fracture, height should be affected but the arm span should not be affected in most of the subject. Nores et al. found that a difference between arm span and height of 5 cm or more was highly predictive of vertebral fractures [6]. Versluis et al. studied the usefulness of arm span and height comparison for detecting vertebral deformities in 494 women. They found that there was only a small difference between the height and arm span in both groups, with vertebral deformities and without vertebral deformities. Though they concluded that the presence of vertebral deformities could not be detected by the differences between arm span and height [7], some practitioners believe that a minimum 3-cm difference between the arm span and height is one of the criteria for suspecting osteoporosis [8]. Based on this knowledge, we suggest that to measure height and arm span difference may be an easy physical examination method for predicting postmenopausal osteoporosis. Therefore, we planned this study (a) to assess the relationship between arm span and height, (b) to compare them in postmenopausal and young healthy women.

Materials and methods

There were two groups in this study. Postmenopausal osteoporotic women between 45 and 65 years of age who had menopause at least for 5 years were included in group I according to the World Health Organization (WHO) criteria. Healthy young women who were given the Turkish version of 1-min osteoporosis risk test [9] and who did not have risk factors for osteoporosis were included into group II.

Individuals having severe spinal osteoarthritis and spinal deformities such as scoliosis, spinal surgical procedures, traumatic or pre-menopausal vertebral fractures, upper and/or lower extremity growth abnormalities or skeletal dysplasia were not included in the study. The presence of secondary causes of osteoporosis was also an exclusion criterion for this study.

Anthropometric measurements

Height, weight and arm span of the individuals were measured by the same investigator using the same measuring devices for all. Height was measured with the individual standing barefoot on the scale (Fig. 1). Arm span was measured with a flexible meter from the tip of the middle finger on one hand to the tip of the middle finger on the other hand with the individual standing with her back to the wall with both arms abducted 90°, elbows extended and palms facing directly forward (Fig. 2). All measurements were taken with the same meter.

Weight was measured with the individuals standing on the scale without shoes. Body mass indexes (BMIs) were calculated by dividing the body weights (kg) by the square of heights (m^2).

Fig. 1 The method for measuring height

Fig. 2 The method for measuring arm span

Radiological examination

Lateral dorsal and lumbar spine radiographs of postmenopausal women were obtained. Anterior height, central height and posterior height of vertebrae were measured. The presence of deformity in each vertebra was assessed as wedge, biconcave and complete compression deformities.

Wedge deformity was defined as at least 30% reduction in anterior height relative to the posterior height of the same vertebra. Biconcave deformity was defined as at least 20% reduction in the middle height of vertebra. Minimum 45% reduction in the anterior and posterior height of vertebra was classified as complete compression fracture [10]. All radiological examinations were evaluated by the same investigator. Subjects having osteoarthritis and osteophyte formation at radiological examination were excluded from the study.

Bone mineral density measurement

Bone mineral density (BMD) was measured using a dual energy X-ray absorptiometry at the lumbar spine (L2–4) and femur. If the fractured vertebra was in this area, the vertebra was excluded from the analysis. A value for BMD or bone mineral content that varied between 1 and 2.5 below the young adult mean was accepted as osteopenia. If the value was below the young adult mean, it indicated osteoporosis according to the WHO criteria [1] and only osteoporotic women were included in the study.

Statistical analysis

SPSS 10.0 was used in statistical analysis; postmenopausal women and healthy young women were compared by unpaired *t*-test. Pearson correlation coefficient was performed for evaluating the relationship between anthropometric values, BMD and presence of vertebral fracture.

Results

Seventy postmenopausal osteoporotic (group I) and 70 healthy young (group II) women were included in the study from our Osteoporosis Out-Patient Clinic and medical students or Hospitals' employees in our University Hospital, respectively, for group I and II.

The demographic values of group I and II are shown in Table 1. Mean age of postmenopausal women was 64.4 ± 8.6 years and mean age of young healthy women was 27.3 ± 3.5 years. Mean BMIs in group I and group II were 29.2 ± 6 and 22.3 ± 3.5 kg/m^2, respectively. Mean height of postmenopausal women was 152 ± 5.1 cm and mean height of healthy young women was 161.5 ± 5.9 cm. Mean arm span length was 159.6 ± 6.3 cm in postmenopausal women and 163.5 ± 6 cm in young healthy women. Mean arm span–height difference was significantly higher in postmenopausal women when compared to healthy young women (7.7 ± 3.6 and 2 ± 2.9 cm, respectively, $P < 0.001$).

Of the postmenopausal women, 24.3% ($n = 17$) had at least one vertebral fracture, 12 had multiple fractures in various levels of lumbar and thoracic vertebra. Most of the fractures were in the 12th thoracic and first lumbar vertebra. Of the vertebral deformities, 11.4% were biconcave, 4.3% were anterior wedge and 8.6% were complete compression fracture.

Table 1 Demographic characteristics of subjects

	Group I ($n = 70$)	Group II ($n = 70$)	*P*-value
Age (year; mean ± SD)	64.4 ± 8.6	27.3 ± 3.5	<0.0001
Weight (kg; mean ± SD)	66.8 ± 12.9	57.5 ± 9.8	<0.0001
Height (cm; mean ± SD)	152 ± 5.1	161.5 ± 5.9	<0.0001
BMI* (kg/m^2; mean ± SD)	29.2 ± 6	22.3 ± 3.5	<0.0001
Arm span (cm; mean ± SD)	159.6 ± 6.3	163.5 ± 6	<0.0001
Height–arm span differences (cm; mean ± SD)	7.7 ± 3.6	2 ± 2.9	<0.0001

BMI body mass index

Correlation analysis of values of postmenopausal women is shown in Table 2. Height declined with age ($r = -0.26$, $P = 0.02$) and there were negative correlations between age and arm span ($r = -0.22$, $P = 0.05$); vertebral fracture and height ($r = -0.31$, $P = 0.01$). Although height decrease was more pronounced in postmenopausal women with vertebral fractures than in others, no statistically significant difference was found between vertebral fracture and arm span. Vertebral fracture was related to loss in BMD ($r = -0.36$, $P = 0.02$) and increased age ($r = 0.3$, $P = 0.02$). On the other hand, femur neck *T* score was positively correlated with weight ($r = 0.34$, $P = 0.04$) and BMI ($r = 0.29$, $P = 0.01$).

Discussion

Prevalence of vertebral fractures increases with age in osteoporotic women [2,3]. There is clear evidence that the presence of a vertebral fracture increases the risk of future fractures [11]. Furthermore longitudinal studies in women with clinically apparent vertebral fractures suggest that these are associated with a subsequent increased risk of non-vertebral fractures [12–14]. Vertebral fractures have a

Table 2 Correlation analysis of the parameters

	r-value	*P*-value
Age–height	−0.26	0.002
Age–arm span	−0.22	0.05
Vertebral fracture–height	−0.31	0.01
Vertebral fracture–lumbar *T* score	−0.36	0.02
Age–vertebral fracture	0.3	0.02
Femur neck *T* score–weight	0.34	0.04
Femur neck *T* score–body mass index	0.29	0.01

substantial negative impact on patient's function and quality of life. Its importance lies not only in the morbidity that arises but also in the fact that it serves as a risk for further fractures. Radiological examination should be obtained when osteoporotic fracture is suspected. However, only one-third of osteoporotic vertebral fractures give rise to symptoms, therefore many times X-ray of vertebrae could not be obtained [4]. Clinical consequences of osteoporotic vertebral fracture are kyphosis and loss of height. Ettinger et al. [15] investigated if kyphosis was associated with substantial chronic back pain and disability. Their study also investigated the existence of any relationship between kyphosis and height loss in 610 women, aged 65–91 years. The findings have shown kyphosis was associated with decreased BMD and loss of height. The mean height loss of kyphotic women was 5.5 cm compared with 3.1 for the remainder. Even though they did not measure arm span and evaluate the relationship between arm span and height, they showed that BMD, vertebral deformities (such as kyphosis) and loss of height were well correlated with each other as being the case in our study.

Mohanty et al. investigated the relationship between different anthropometric measurements and standing height of South Indian women. They concluded that arm span was the most reliable body parameter for predicting the height of an individual and believed that it was useful in predicting age-related loss in stature [16]. Several other studies have reported the effectiveness of using various body parameters in predicting body height; arm span was found to be the most reliable paremeter [17,18].

A positive correlation between these anthropometric measures and bone mass was well documented. Both weight and BMIs were clearly associated with BMD [19,20]. These findings are parallel to ours. In our study, femur neck *T* score was positively correlated with weight and BMI, confirming the results of previous studies. In addition, the present study assessed the relationship between arm span and height of postmenopausal osteoporotic women and those of healthy young women. We have also evaluated whether there was an association between these anthropometric measures and vertebral deformities. We have found that the mean arm span–height difference was higher in postmenopausal women than in healthy young women. However, we did not find any direct association with vertebral fractures and the difference between arm span and height. Wang et al. investigated if the difference between arm span and standing or sitting height could be used to identify patients with fractures [21]. Their findings have shown that the difference between arm span and standing or sitting height could not be used to predict vertebral fracture risk.

The difference between arm span and height increases with age; the mean arm span–height difference in our study was significantly higher in postmenopausal women when compared to healthy young women. Mean arm span–height difference in young healthy adults was less than 3 cm (2 ± 2.9 cm). This finding is correlated with previously reported literature [6–8]. Trivitayaratana et al. studied the comparison of arm span, height and forearm BMD in normal young and postmenopausal women. They suggested that arm span could be used to predict the height during the younger adult life of elderly women and to predict the current height in patients who had a height loss problem [22]. Manonai et al. investigated the relationship between arm span and height in women of different age groups (young, perimenopausal and postmenopausal). Their findings were similar to ours as well. They found that height and arm span were well correlated and could be used interchangeably in young women. The correlation decreased with advancing age. Since arm span has not changed with age, they concluded that there was a decrease in height among women of increasing age, using arm span as the reference to the previous height [23].

In another study from our country, 90 women (mean age—59.3 years) were investigated in terms of height and arm span difference [24]. They were divided into two groups as osteoporotic ($n = 51$) and non-osteoporotic ($n = 49$). The authors found that there was no difference in terms of arm span and height difference value between these two groups. However, they did not compare the subjects with the young women. In our study, we compared the postmenopausal osteoporotic women with young women and the value was statistically significant between two groups. When the comparison was done between osteoporotic women with and without vertebral fracture there was no significant difference in terms of arm span–height difference value in our study. This finding was similar with those in Uzunca's study.

In conclusion, arm span is a valid measure of height in young and middle-aged adults [25]. Although the sample size of the study was less, arm span measurements can be used in estimation of youth height and age-related loss in stature. However these type of studies should be done with much bigger sample size in future; we suggest that, the ratio of height to arm span is an important factor to determine the loss of height in postmenopausal osteoporotic women.

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