Research Article

Investigating the Difference Between Thoracic Kyphosis and its Mobility in Community-Dwelling Older Men and Women

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ABSTRACT

Introduction: The amount of thoracic kyphosis and its mobility may be affected by gender in older adults. This study investigates gender differences in thoracic kyphosis and thoracic spine mobility in healthy older adults.

Materials and Methods: In this cross-sectional study, 36 participants among which 21 were female and 15 were male with an age range of 65-80 years participated. The amount of thoracic spine kyphosis was measured in a relaxed standing position and the position of maximum correction of thoracic kyphosis using a flexible ruler between the spinous processes of T12 and C7. The difference between the thoracic kyphosis of the relaxed state and the condition of the maximum correction is used to determine the degree of thoracic spine mobility. Finally, men and women were compared in terms of thoracic kyphosis and thoracic spine mobility. The student t-test was employed to compare kyphosis and spinal mobility between men and women, and the paired student t-test was used to compare kyphosis angle in a relaxed posture and maximum kyphosis correction status. Meanwhile, the Pearson test was utilized to evaluate the relationship between variables.

Results: Although there was no statistically significant difference in the mean thoracic kyphosis of relaxation (P=0.13) and maximal correction (P=0.18) status of healthy old men and women, there was a significant positive relationship between the rate of kyphosis angle and the amount of mobility of thoracic kyphosis (P=0.003; r=0.48).

Conclusion: There is no difference in the degree of kyphosis and thoracic spine mobility in older men and women. In addition, people with more thoracic kyphosis had more spinal mobility.

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Introduction

In a standing position, kyphosis is a curvature of the spine caused by the form of the vertebrae, intervertebral discs, and paraspinal muscles [1]. The normal values of kyphosis are in the range of 20 to 40 degrees and rise above 40 degrees after the fourth decade of life [2]. This frequent age-related postural alteration is known as hyperkyphosis and in a large cohort study, the prevalence of hyperkyphosis in men and women aged 60 to 70 years was 14% compared to 28%, respectively [3]. It has a negative effect on physical function [4, 5], respiratory function [6] postural control, [7] independence [8], general health [9], quality of life [10], balance, and performance [11] and may interfere with spinal mobility [12-14].

Degenerative disc disease and family variables, aging, vertebral fractures, low bone density, and muscle weakness are substantial risk factors for hyperkyphosis in elderly men and women [13-18]. On the other hand, evidence suggests that a growing kyphosis angle is connected with a decline in mobility and physical function in community-dwelling seniors, especially in women [1, 11, 19]. Mika et al. (2009) suggested that the spinal range of motion in active women was greater than in sedentary ones [20].

Women may be at higher risk of hyperkyphosis due to hormone changes with menopause and other sex-related factors, such as poor spinal extensor muscle quality, low spinal muscle strength and endurance, low bone mineral density, vertebral fractures, and the weight of hanging breasts [21-23]; however, there is a contradiction in the results of research literature.

Fon et al. (1980) reported that, among participants aged 2-77 years, the rate of increase in kyphosis by age in women is higher than in men [24]; however, in the study by Katzman et al. (2017), men had more kyphosis than women; however, this difference was not statistically significant [25]. Zappala et al. (2021) in a systematic review reported that ethnicity could affect the degree of kyphosis, but not gender [26].

According to Hinman (2004), healthy older women show more kyphosis and less mobility in their thoracic spine compared to younger women, which shows that increasing thoracic kyphosis increases spinal stiffness and reduces spinal mobility [12].

Despite the factors that predispose women to a greater increase in thoracic kyphosis [23] as seen in the research literature, there is a contradiction regarding the effect of gender on the amount of kyphosis, such that Fon et al. confirmed that kyphosis is more in woman [24], Katzman et al. maintained that kyphosis is less in women [25], and Zappala et al. demonstrated that gender has no effect on the amount of kyphosis [26]. In addition, no published study was available to the researchers of the present study that compared the mobility of the thoracic spine between elderly men and women. Accordingly, this study assesses and compares the amount and mobility of thoracic kyphosis in male and female community-dwelling older adults.

Materials and Methods

The participants in this analytical-descriptive study were 36 healthy older individuals (21 females and 15 males) aged 65-80 years. The sample size of 15 for each group was calculated using G*Power software, version 3.1.9.4, based on the result of our pilot study (α=0.05; β=0.2).

Individuals were recruited using a simple sampling method from the people referring to the Elderly Cultural Center in Tehran City, Iran. The inclusion criteria were having between 65 to 80 years of age and being community-dwelling. Meanwhile, the exclusion criteria were having a history of spinal tuberculosis, spinal surgery, radiation, tumor, neuromuscular disease, history of spinal fracture or bone disease, back pain, osteoporosis, or hyperkyphosis.

First, the subjects signed an informed consent. The height and weight were measured and the body mass index (BMI) was calculated using weight in kilograms (kg) divided by the square of height in meters (m^2). Subsequently, the kyphosis arc was measured by a 60 cm long flexible ruler [27, 28], between the spinous processes of C7 and T12 vertebrae.

The greatest fixed spinous process in the neck was determined as the C7 spinous process. The examiner placed a finger on the C7 spinous process, while the other finger was placed on the easily palpable C6 spinous process [10, 19, 29]. Moreover, the location of the T12 spinous process was identified by connecting the lower side of the two posterior superior iliac spines, the midpoint of the two was identified as the S2 spinal vertebra. After that, the participant was requested to stand up straight while the examiner's finger was on the T12 spinous process and the location of the spinous process was marked in this posture to reduce the inaccuracy caused

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Figure 1. Modeling of thoracic kyphosis arch with flexible ruler

by skin movement [30, 31]. Hoppenfeld's method was used to ensure the correct location of the spinous process (to reach the T12 spinous process, the inferior border of the 12th rib on two sides was touched by the thumb and then the two thumbs were moved up and down simultaneously on both sides until the rib disappeared under the soft tissue), the midpoint of the distance between the two thumbs was considered to be the T12 spinous process [32]. To ensure the accuracy of the landmarks, both examiners in each individual identified them. In the next step, the person stood barefoot with each arm hanging on either side of the body, while feet were 15 cm apart. The person was asked to be in a comfortable position while distributing their weight evenly on both feet and looking at a fixed point on the opposite wall and remain in this position for 3 minutes to reach their normal state. The stabilizer was placed on the sternum to keep the person from swinging freely on the sagittal plate while the measurement was being taken. The thoracic arch was modeled on the flexible ruler, which was put on the spinous processes between C7 and T12 (Figure 1). Finally, the shape was transferred to paper. The length and width of the arc were computed first on the arcs recorded by the flexible ruler, and then the amount of angle of kyphosis or θ was estimated using Equation 1.

1. $\theta=4 (\arctan [2h/l])$ [33]

Khalkhali et al. (2003) reported that the validity of measuring dorsal kyphosis using a flexible ruler by this formula compared to dorsal radiographs is 89% [28]. To measure the mobility of the thoracic spine, the person was asked to straighten their spine as much as they could while standing, without raising the shoulders or lifting the legs off the ground. In this case, the flexible ruler was again placed between the spinous processes C7 and T12, and the arc shape was drawn. The difference between the kyphosis angle in a relaxed posture and maximal correction status shows the degree of thoracic spine mobility, which higher numerical value, indicates more mobility of the thoracic spine [12]. Findings were analyzed using the SPSS software, version 16. The Shapiro-Wilk test was used to assess the normality of the distribution of data, the student t-test to compare kyphosis and spinal mobility between men and women, the paired student t-test to compare kyphosis angle in a relaxed posture and maximum kyphosis correction status, and the Pearson test to evaluate the relationship between variables.

Results

Due to the normality of the distribution of variables, parametric tests were used to analyze the data. According to Table 1, the two groups of men and women were not significantly different in terms of demographic profile (age and weight).

According to Table 2, the degree of thoracic kyphosis as well as the amount of thoracic spine mobility between the two sexes were not significantly different by the student t-test ($P>0.05$). The mean values of kyphosis both in relaxed and maximal correction positions were higher in men compared to women; however, this difference was not statistically significant ($P=0.13$; $P=0.18$).

According to the Pearson test results, there was a significant positive relationship between the rate of kyphosis angle and the amount of mobility of thoracic kyphosis ($P=0.003$; $r=0.48$). In other words, the more kyphosis angle in a relaxed position, the more mobility of the thoracic spine. The amount of kyphosis in a relaxed standing position and the amount of kyphosis in a standing position with maximum correction of thoracic kyphosis showed a significant difference ($P=0.001$). On average, individuals reduced their kyphosis angle by 6.4±5.6 degrees by maximal correction of thoracic kyphosis.

In addition, there was a weak negative and statistically significant relationship between the mobility of the thoracic spine and body mass index ($P<0.05$; $r=-0.31$); accordingly, a higher body mass index indicates less mobility of the thoracic spine.

Discussion

In this study, the amount of thoracic kyphosis in healthy elderly men and women was measured and compared. Moreover, the degree of thoracic spine mobility in men

Table 1. Comparing the demographic profile of participants

Variables	Mean±SD		P
	Male (n=15)	Female (n=21)	
Age (y)	70.9±4.4	68.5±4.7	0.16
Weight (kg)	63.6±9.3	69±11.3	0.33
Height (cm)	172±12	165±7	0.08
BMI (Kg/m^2)	21.75±9	25.8±2.1	0.23

BMI: Body mass index; SD: Standard deviation.

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Table 2. Comparison of the thoracic kyphosis and spinal mobility in two standing positions between men and women

Variables	Mean±SD		P
	Male (n=15)	Female (n=21)	
Kyphosis angle in relaxed posture (degree)	54.1±10.5	47.3±14.5	0.13
Kyphosis angle in maximum correction of kyphosis status (degree)	46.7±12.1	41.5±11	0.18
Thoracic mobility (degree)	7.3±6.3	5.8±5.1	0.45

SD: Standard deviation.

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and women was compared. According to the results, contrary to the researchers' hypothesis that women may have more thoracic kyphosis due to the expected changes after menopause in older women [21-23], the kyphosis was even slightly higher in older men than in older women; however, this difference was not statistically significant. Our results are in line with Giglio and Volpon (2007) who found that the thoracic kyphosis angle of 718 men and women aged 5-20 years had no difference between the sexes, but reported a linear increase in kyphosis with age; meanwhile, the age range of the two studies is different [34]. In addition, Milne and Williamson (1983) in their cross-sectional study, even though they observed a greater increase in kyphosis angle by age in women than men, their longitudinal study over 5 years did not confirm it [35]. Our result is comparable with the findings of Katzman et al. (2017) who reported that men had greater kyphosis than women at baseline and before strengthening exercise but this difference was not significant [25]. Our finding also is comparable to a suggestion by Zappala et al. (2021) that gender does not affect the degree of kyphosis [26].

The findings of our study were inconsistent with the findings of Milne and Lauder (1974) and Fon et al. (1980) who showed a higher rate of kyphosis in women [24, 36]. On the other hand, Mellien et al. (1992) suggested that girls have less thoracic kyphosis than boys [37]. In addition, age-related reductions in thoracic kyphosis were seen in a longitudinal study of females [38]. However, in these studies, given the age range of participants in the study was wider, this difference in the results can be justified.

Our finding is also inconsistent with the suggestion of Boyle et al. (2002) who, in their experiences as spinal surgeons, reported that among older men and women with spinal hyperkyphosis, women had a greater kyphosis angle than men [39]. This difference is because the observations of these surgeons were on hyperkyphotic individuals [40]. Moreover, Urrutia et al. (2021) found that the depth of the back arch is greater in women than in men; however, the angle of the arch was not computed and just the depth of the arch was measured. The length and depth of the back arch are both utilized to determine the kyphosis angle [41]. Pan (2019) in a systematic review and meta-analysis suggested that heterogeneity might partly explain why heterogeneous sizes and different mean ages produced contradictory results [42].

Our study suggested that there is not any difference in the thoracic spine mobility between women and men. Although there was no similar study available to compare the results of our study, Pan (2019) showed that in each decade of age range, sex had a variable impact on spinal mobility, and it varied depending on the different spinal regions and anatomical directions [42]. Our finding demonstrated that those with more kyphosis could adjust the amount of thoracic spine kyphosis, implying

that they had more spinal mobility. Our results are contrary to the results of Hinman who showed that healthy older women have more kyphosis and less mobility in their thoracic spine compared to younger women and concluded that increasing the thoracic kyphosis increases the spinal stiffness and reduces the spinal mobility. Their study was only on women, while our study shows the results both on women and on men. The difference between the two groups in the study by Hinman may not be because of more kyphosis, but because of the age difference and the changes caused by it. One possible explanation for the observed results in our study may be that the more kyphosis is more away from the erect posture so there is more available range and it is reasonable to allow for more adjustment and movement.

Based on our findings, the quantity of thoracic spine mobility could be reduced when the body mass index rises as an effective factor, although weak, in increasing stiffness and reducing spinal mobility.

Conclusion

There is no difference in the degree of thoracic kyphosis and thoracic spine mobility in healthy-aged men and women. In addition, persons with more thoracic kyphosis had more spinal mobility and less stiffness, and the rate of the mobility of the thoracic spine decreased as the body mass index increased.

The results of this study can be used to determine how gender affects the prevalence of dorsal kyphosis in the elderly.

Study limitations and research suggestions

The small number of samples was the main limitation of this study. It is recommended to repeat this study in a larger population of healthy older people and hyperkyphotic people. In addition, in the present study, the bone density of the participants we not examined and measured. However, due to the importance of bone changes in spinal health and vertebral shape, a similar study would be valuable considering this variable.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (Code: IR.SBMU. RETECH.REC.1398.410).

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Authors' contributions

Supervision: Minoo Khalkhali Zavieh; Conceptualization: Tayebeh Roghani, Somayeh Mahmoodiaghdam, and Maryam Nodehi; Methodology: All authors; Data collection: Somayeh Mahmoodiaghdam and Maryam Nodehi; Investigation: Somayeh Mahmoodiaghdam, Maryam Nodehi; Data analysis and writing the original draft: Somayeh Mahmoodiaghdam, Maryam Nodehi, Himan Aryanfar and Alireza Akbarzadeh Baghban; Review and editing: Minoo Khalkhali Zavieh.

Conflict of interest

The authors declared no conflict of interest.

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