Relation between Back Extensor Strength, Bone Mineral Density, Kyphosis and Lordosis in Elderly Women

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Abstract—*Kyphosis and lordosis changes might be related to back extensor weakness and osteoporosis. The purpose of this study was to find out the correlations between thoracic kyphosis, lumbar lordosis with back extensor strength (BES) and bone mineral density (BMD).*

Methods: *Thoracic kyphosis, lumbar lordosis, maximal isometric strength of the back extensors and BMD of the lumbar vertebral were evaluated in 47 elderly (50-75 years old)women. BMD of the lumbar vertebral was measured using Dual-Energy X-Ray Absorptiometry (DEXA) and kyphosis and lordosis degree were assayed using a flexible ruler. The maximal isometric strength of the back extensors was measured using an isometric manual muscle tester (MMT). Data were analyzed using ANOVA and independent t-test at p≤0.05 level of acceptance.*

Results: *A significant reverse correlation was shown between BES and kyphosis (p=0.044, r=-0.30). No significant correlation were found between BES and lordosis degree, nor between lumbar vertebral BMD and, both, kyphosis and lordosis degrees. However, there was a significant difference in BES between three groups with various degree of kyphosis (p≤ 0.05).*

Conclusion: *It can be concluded that the severity of thoracic kyphosis may be influenced by BES. So, stronger back extensor can prevent thoracic kyphosis despite decreased BMD.*

Key Words: Bone Density, Muscle Strength, Kyphosis, Lordosis.

I. INTRODUCTION

In people who are afflicted with osteoporosis it has been observed that increasing the degree of vertebrae under pressure and progressive changes of pulling line of body gravity will usually result in anterior deformity of the spinal cord or kyphosis.[1] The kyphosis occurrence in these people could be accompanied with height loss, rib-cage deformity, respiratory dysfunction, and abdominal protrusion.[2] However, no significant relationship was indicated between BMD and kyphosis deformity according to Mika *et al.* who stated that any reduction in BMD could not lead to increasing the angle of kyphosis if back extensor strength (BES) and degree of spinal cord stability had not changed.[2] According to the findings of the previous studies,[2,3] weak back muscles are observed among people who afflicted with kyphosis,[3] although, this relationship was not significant in a previous study [2] but, when these subjects were categorized according to their BMD, this relationship was significant; in other words, the kyphosis angle was more in individuals who had weaker back muscles, and this difference increased with lowering of BMD.

Women are more exhibited than men to low bone mass and its complications, so that fracture in hip bone is 5.2 and in vertebra is 10 in women v/s 1 in men[4].

Generally, women have weaker back muscles in compare to males, and reduced strength of these muscles has more destructive effects on musculoskeletal system through aging. Sinaki *et.al*[5] indicated

that the stronger the back extensor, the smaller the thoracic kyphosis and the larger the lumbar lordosis and sacral inclination. They concluded that back extensor strength is an important determinant of posture in healthy estrogen-deficient women. However it is cleared that the back extensors strength lowers and angle of kyphosis increases with age. According to Sinaki *et al*.[5] back extensors strength had a significant negative correlation with thoracic kyphosis and a positive correlation with lumbar lordosis and sacral inclination which can be explained considering the anatomical position of these muscles. It is, also, indicated that life style has a relationship with posture, which this could be related to the amount of activity of daily living and in turn BES[5]. So, the aim of this study was to find out the relationship between spinal cord alignment in sagittal plane, BMD and BES in elderly women.

II. METHODOLOGY

A cross-sectional analytic type of observational study was carried out on 47 elderly women attending at centre for bone marrow density test.

Approval for this study was taken from Ethics committee of Yadegar - e- Imam Khomeini (RAH) Shahre-rey Branch, Islamic Azad University. After taking approval from institutional Ethical committee, study subjects were selected. Age 50-75 years old women were selected for this study from the subjects who referred at this centre for the bone mass testing. Subjects who had a history of spinal cord surgery, herniated disc and chronic back pain were eliminated. All subjects completed the consent form. Finaly 47 eligible women were included in this study. After taking consent from each subject, these women were interrogated as per predesigned performa and were subjected for further following assessments.

2.1 Kyphosis and LordosisMeasurements:

Kyphosis and lordosis curves were measured using a flexible ruler as a valid and reliable technique[6]. A fixing instrument was used in order to higher the precision of measuring the spinal cord curves according to Youdas *et al.* (2006) [7]. To this, participants were asked to stand in the normal anatomical position. First lumbar (L_1) and second sacral (S_2) vertebrae were considered as markers for evaluating the lumbar curvature. In order to find S_2, the posterior superior iliac spine (PSIS) was marked. The midpoint between the two PSISs was considered as the spinous process of the S_2.

To find L_1, the examiner pushed the lower back above the iliac crest in order to move the soft tissue laterally where the two thumbs reach horizontally together on the L_4spinous process. The L_1spinous process was identified by counting up the vertebrae. Then, the flexible ruler was located on $L_1$and S_2while a hand pressed on it to abolish the gap between the ruler and the skin. The ruler was put on a page and the lumbar curve was drawn afterwards[8].

Measurement of the thoracic curvature was done in a similar method to that of the lumbar curvature. The only difference was that T2 and the joint of T12 and L1 were marked in order to measure the thoracic curvature[9]. The thoracic curve was drawn by using a flexible ruler. Two ends of the curve reached together, and a L line was drawn whose midline vertically reached the middle of the curve through the h line. The lengths of h and L lines were calculated and the aforementioned angle was obtained. The line was drawn from the side of the ruler which touched the skin. The kyphosis and lordosis angles were measured separately by the tangent method[10,11].

$$\theta = 4 \arctan 2\, h/L$$

The normal range of kyphosis and lordosis were considered between 20 to 40 degrees and 20 to 45 degrees, respectively[12] and all subjects were categorized into three groups of normal, lower than normal and higher than normal, accordingly.

2.2 Bone Mineral Density

The bone density of the spinewas measured at L2 to L4 using dual-energy X-ray absorptiometry (DEXA) system (model Lexxos DR, DMS Group, France).The relative degree of risk of fracture (normal, low, average, and high), and WHO scale (normal, osteopenia, and osteoporosis) was determined according to T score.

2.3 BES Assessment

The subjects were positioned prone on a treatment table with their hands behind their head and distal thighs secured to the table with a stabilization strap. The Manual Muscle Test (MMT) dynamometer (Morgan Hill, CA, U.S.A) was placed such that the center of the force pad bisects a line connecting the superior/medial angle of the subject's scapulae. A strap was then secured over the dynamometer and around the underside of the table. To limit the contribution of hamstring activity on trunk extension strength, the subject's feet were supported on a bolster in 30°of knee flexion. Instructions for the subjects were to lift their trunk upward with maximal effort. The maximum record in two efforts was assumed as BES. The test–retest reliability of the force measurements (ICC) for this measure is reported to be 0.85[13].

2.4 Statistical Method

The normality of the data was assessed using Kolmogorov–Smirnov test. The relationship between the variables and the difference between the levels of deformity according to weight and age were analyzed using ANOVA and Pearson correlation coefficient, respectively. Statistical analysis were done using SPSS 16.0 (trial version) for windows and significant level was set at $p \leq 0.05$.

III. RESULTS

In this present study, mean and standard deviation of the variables as per their age group are presented in table 1. It was observed that although there was a significant difference as per age in weight, BMI and lordosis but not in other variables studied. (Table 1)

Table 1
Characteristics of the subjects as per Quantitative Variables

S. No.	Quantitative Variables	Age Groups (Mean ± SD)		Unpaired 't' test
		50-60 Years (N=23)	>60 Years (N=23)	P value LS
1	**Weight (Kg)**	77.9±1.1	67.8±8.0	6.128 at 45 DF <0.001 **S**
2	**Height (Cm)**	155.0±4.3	157.2±3.8	-1.856 at 45 DF 0.070 NS
3	**BMI (kg/m^2)**	32.4±4.2	27.5±3.9	4.140 at 45 DF <0.001 **S**
4	**Spinal Cord T-score**	-1.5±2.0	-2.1±1.4	1.187 at 45 DF 0.242 NS
5	**BMD$_{L2-L4}$ (g/cm^2)**	0.9±0.3	0.84±0.3	0.685 at 45 DF 0.497 NS
6	**BES (Kg)**	3.6±2.4	3.5±2.4	0.143 at 45 DF 0.887 NS
7	**Lordosis (Degree)**	36.4±1.2	31.9±1.4	11.848 at 45 DF <0.001 **S**
8	**Kyphosis (Degree)**	43.6±1.6	44.3±1.5	-1.546 at 45 DF 0.129 NS

BMI: Body Mass Index; BMD: Bone Mineral Density; BES: Back Extensor Strength

Table 2 is showing the absolute and relative frequency of kyphosis and lordosis, WHO scale and relative degree of the risk of fracture. It is observed that maximum women were of high Kyphosis degree (57.5%) and normal lordosis (55.3%). WHO criteria for BMD observed Osteoporosis in 34.8% women and fracture risk was found medium to high in 34%. (Table 2)

Table 2
Frequency of subjects in each group-variable

Variables	Degree	Frequency	Relative Frequency
Kyphosis	**Low**	4	8.5
	Normal	16	34.0
	High	27	**57.5**
Lordosis	**Low**	10	21.3
	Normal	26	**55.3**
	High	11	23.4
WHO Criteria	**Normal**	15	32.6
	Osteopenia	15	32.6
	Osteoporosis	16	**34.8**
Fracture Risk	**Normal**	12	25.5
	Low	19	40.4
	Medium	9	**19.1**
	High	7	**14.9**

On analysis with Pearson correlation, a significant relationship was found between level of kyphosis with BES ($r=-0.295$ $p<0.05$). There was no significant correlation was found between the other variables studied. (Table 3).

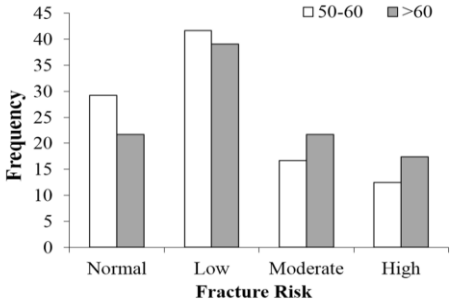
Table 3
Relationship between variables

Variables	Variables	R	P Value
Kyphosis	**BES**	**-0.295**	**0.044**
	BMD	0.191	0.198
Lordosis	**BES**	0.068	0.647
	BMD	0.055	0.715

BMD: Bone Mineral Density; BES: Back Extensor Strength. R= Pearson correlation

No significant difference was shown in level of kyphosis and lordosis between 3WHO criteria-based groups (i.e. normal, osteopenia, and osteoporosis) ($p>0.05$).Relative risk of fracture among 50-60 and >60 years old is presented in Figure 1;a tendency of having higher relative risk of fracture exists in >60 years old people. There was no significant difference in BES between groups with differentdegree of lordosis; although, LSD post-hoc test revealed a significant difference between normal and high degree kyphosis ($p\leq0.05$). (Figure 1)

Figure 1
Age wise frequency of subjects based on fracture risk



IV. DISCUSSION

The observations of present study indicate that 57.5 percent of the subjects were inflicted with high degree of kyphosis and 23.4 percent with high degree of lordosis. Mean BMD in 50-60 years old group was 0.90±0.28 $g.cm^{-2}$against0.84±0.25 $g.cm^{-2}$in>60 years old group which is lower than the BMD (1.066 ± 0.175 $g.cm^{-2}$) that reported by Sinaki *et.al*[5] in healthy group. It has to be mention that the subjects of the present study were the people with pathologic signs of low BMD who were referred by a physician to "Bone Density Testing Center".Accordingly,34.8 percent of our subjects were inflicted by osteoporosis and 32.6 percent with osteopenia.

A significant relationship was found between BMD and kyphosis and lordosis angle nor significant difference in degree of kyphosis and lordosis between normal subjects andosteopenia or osteoporosis ones. Mika *et al.*[2] also did not indicate a significant relationship between BMD and kyphosis deformity. They stated that reduced BMD without any changes in back BES and spine stability could not lead to increasing the angle of kyphosis. However, others [5]did not support this findings. In this regard, a review[14] has reported that the severity of wedging increases as BMD losses, causing greater numbers of vertebral compression fractures and a further cascade of increasing hyperkyphosis. On the other hand, few older studies indicated that the changes in spinal-cord soft tissues could increase the kyphosis angle.[5,15]

In the present study a significant relationship was found between BES and kyphosis angle. There is a significant difference in BES according to level of kyphosis, and after performing the follow-up LSD test it was indicated that in BES between normal kyphosis group and more than normal group that there was a significant difference existed ($p \leq 0.0.5$).

In few studies likes the present one, increased angle of kyphosis was associated with a reduction in BMD that may be related to other factors such as changes in spinal cord soft tissues. In another study, no vertebral deformities was reported in only 17 percent of the individuals with kyphosis[16]; additionally, 48 percent of the individuals with kyphosis were affected by vertebral deformity accompanied by reduction in BMD.[5] In this regard, Mika *et al*. according to their multi-variable analysis study stated that weakness of back muscle is the more important cause for spinal cord deformities than reduced bone mass when osteoporosis is existing.[2]

A significant relationship between BES and BMD was also reported in menopause women [17] and patients with osteoporosis.[18] Sinaki *et al*. indicated that muscle strength reduction was observed specifically in back muscles not whole body, so that no significant difference was existed in handgrip test between osteoporosis and healthy group. These findings indicate that the difference in BES between healthy and osteoporotic groups may be because of pain, discomfort and lack of adequate stimulation of these muscles.[5] In the longer term, both muscle and bone mass increased in patients with rheumatoid arthritis over a strength training program,[19] whilst the increase in lean muscle mass was the best predictor of gain in femoral bone content and density in exercising children,[20] highlighting an existed relationship between muscle strength and BMD. However, few studies were conductedon lordosis and its relationship to BMD and BES.

In this present study the degree of lordosis did not indicate any significant relationship with any studied variables. Gelb *et al*[21] stated that low back lordosis is reduced by age, however, back kyphosis does not change. These investigators also found that reduced lordosis in elderly individuals is because of lack of

balance in vertebrae at sagittal plane.[21] However, Tuzun *etal*. (1999) suggested that this reduction is a secondary illness related to increasing of kyphosis.[12]

Low lordosis was found in 21.3% of the subjects. Significant changes have been observed in level of lordosis by aging.[12,22,23] In a study on relationship between intervertebral discus degeneration and spinal cord alignment in lumbo-sacral region from the sagittal view it was indicated that discus degeneration would lead to reduction in lordosis and sacral angle which will cause the hip to turn backward.[24] Sinaki *et al*. also indicated a positive relationship between BES and lordosis angle which we could say that BES increase could cause reduction in kyphosis angle and increasing of lordosis angle.[5] On the other hand generally women acquire weaker back muscles comparing to men. By aging, the reduction of these muscle strength would have more degenerative effects on women muscular-skeletal system.

In the present study possibility of fracture as a result of aging was higher but this difference was not significant between two groups of 50 to 60 years old and 60 and older. Sinaki *et al*. [5] state that by aging, BES is reduced and kyphosis angle is increased; therefore, it could be stated that the age is an important factor in observing a relationship between BES and kyphosis angle.

V. CONCLUSION

According to the present study, the back extensor muscles have basic role in maintaining the back spinal cord alignment, and it could be stated that increasing of angle of kyphosis could take place as a result of reduction in bone mass, and occurrence of postural deformity in osteoporotic individuals has a close relationship with changes in spinal cord soft tissues the back muscles.

CONFLICT OF INTEREST

None declared till now.

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