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Comparison of thoracic kyphosis and postural stiffness in younger and older women

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Abstract

BACKGROUND CONTEXT: An increase in thoracic kyphosis and postural stiffness is commonly associated with aging and many pathological conditions. Simple clinical measurements are needed to estimate the relative degree of postural stiffness to determine whether clinical interventions, such as exercise, are beneficial.

PURPOSE: To compare the amount of kyphosis and postural stiffness in the thoracic spine of younger and older women.

STUDY DESIGN/SETTING: Experimental design conducted at a large health science center in southeastern Texas.

PATIENT SAMPLE: Fifty-one healthy adult women, 25 between the ages of 21 and 51 years and 26 aged 66 to 88 years.

OUTCOME MEASURES: Index of kyphosis (IK) measured with a surveyor's flexicurve. Differences, percent change and ratios between IK measures taken in the relaxed and maximally erect positions were used to estimate postural stiffness.

METHODS: Subjects were measured while standing in their usual relaxed posture and again in their maximally erect posture by three different raters. IK measures were calculated by each rater and averaged for further data analysis. Independent *t* tests were used to compare the two age groups at the .05 alpha level.

RESULTS: Significant differences were found in both the relaxed ($p=.018$) and erect ($p<.001$) IK measures of younger and older women. The differences, percent change and ratio between the two IK measures were also significantly different in that the younger women demonstrated a greater degree of active reduction of their kyphosis (in the erect posture) than older women.

CONCLUSIONS: Age-related differences in thoracic kyphosis and postural stiffness were documented between younger and older women by means of repeated flexicurve measurements performed in both a relaxed and a maximally erect position.

Keywords: Posture; Spine; Postural assessment; Kyphosis

Introduction

Age-related changes in posture commonly include a forward head, rounded shoulders, increased thoracic kyphosis, reduced lumbar lordosis and flexed hips and knees. These changes are generally attributed to gradual changes in the structure and mechanics of connective tissues which result in a loss of elasticity and inability to effectively counteract the gravitational torque that pulls the body into a forward bent position [1,2]. Certainly, muscle weakness can also affect postural alignment. In one study of older, estrogen-deficient women, investigators reported significant correlations between back extensor strength and the size of the thoracic kyphosis and lumbar lordosis [3]. Accentuated kyphosis is perhaps the most noticeable postural change, particularly in postmenopausal women, who frequently experience a concurrent collapse of the vertebral bodies resulting from low bone density. This type of vertebral deformity has been associated with poor self-esteem, reduced quality of life, functional limitations, increased hospitalizations and mortality resulting from pulmonary compromise, cardiovascular disease or cancer [4–8].

Although several valid and reliable clinical measures of thoracic kyphosis are available, these measurements are

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Nothing of value received from a commercial entity related to this research.

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typically used to document the size of the curve in a single static position. The purpose of this study was to examine the concept of age-related postural stiffness by measuring changes in the size of the thoracic curve of younger and older women when standing in their usual relaxed posture versus their maximally erect posture. Postural stiffness was defined as the inability to actively correct, or improve, the alignment of the spine and reduce the size of the thoracic curve (ie, kyphosis). An experimental design was used to test the hypothesis that older women would demonstrate a greater degree of postural stiffness in their thoracic spine than younger women; thus, there would be a significant difference in the extent to which older women could actively reduce their thoracic kyphosis compared with younger women.

Methods

Sample

An age-stratified sample of 51 healthy pre- and postmenopausal women was recruited from students and staff at a large academic health science center and local community in southeastern Texas. Younger, premenopausal subjects included 25 women between the ages of 21 and 51 years (mean=29.2); the older, postmenopausal sample included 26 women ranging from 66 to 88 years of age (mean=72.3). Menopausal status was determined by self-report. Subjects were excluded for pregnancy, any known spinal pathology or inability to follow verbal directions because of cognitive deficits or language barriers. The university's institutional review board approved this study.

Instrument

A surveyor's flexicurve (Alvin, Hartford, CT) was used to measure the size of the curve (ie, kyphosis) in the thoracic spine and estimate postural stiffness. The flexicurve is a 60-cm-long flexible piece of lead covered in durable plastic that can be molded to the contour of the spine to measure curves in the sagittal plane. The flexicurve provides a quick, inexpensive and noninvasive way to assess posture in clinical or community-based settings. Several investigators have established the validity of flexicurve postural measures by correlating them with measures of kyphosis and vertebral wedging taken from spinal radiographs and other instruments, such as goniometers, kyphometers and inclinometers [9–13]. Flexicurve measures have also been used to identify age-related postural changes, low bone mass, impaired fitness and low back pain [11,12,14,15]. The intra- and interrater reliability of flexicurve measures of thoracic kyphosis are also acceptable with reported coefficients of .88 and higher [16–19]. Normative data have been collected by Milne and Williamson [11], Milne and Lauder [20] and others [14,15] on adults of all ages; however, there does not appear to be consensus regarding a measurement threshold for differentiating between normal and abnormal curvatures.

Data collection procedures

After signing a written consent form, subjects' posture was assessed in two different positions by three graduate students who had been trained to use the flexicurve by an experienced physical therapist. The first measurement was performed with the subject standing in her usual relaxed posture, and the second was taken while she stood in her maximum erect posture. Subjects were asked to loosen the clothing around their waists so the testers could accurately palpate bony landmarks and position the flexicurve (Fig. 1).

The flexicurve measurement protocol (Fig. 2) was based on the one described by Milne and Williamson [11]. Although some investigators have proposed modifications to the calculations used in this protocol to quantify the size of the thoracic kyphosis [17], it continues to be the measurement protocol that is used by most clinicians. First, the tester palpated and marked the spinous process of the seventh cervical vertebra (C7) and the superior aspect of the sacrum

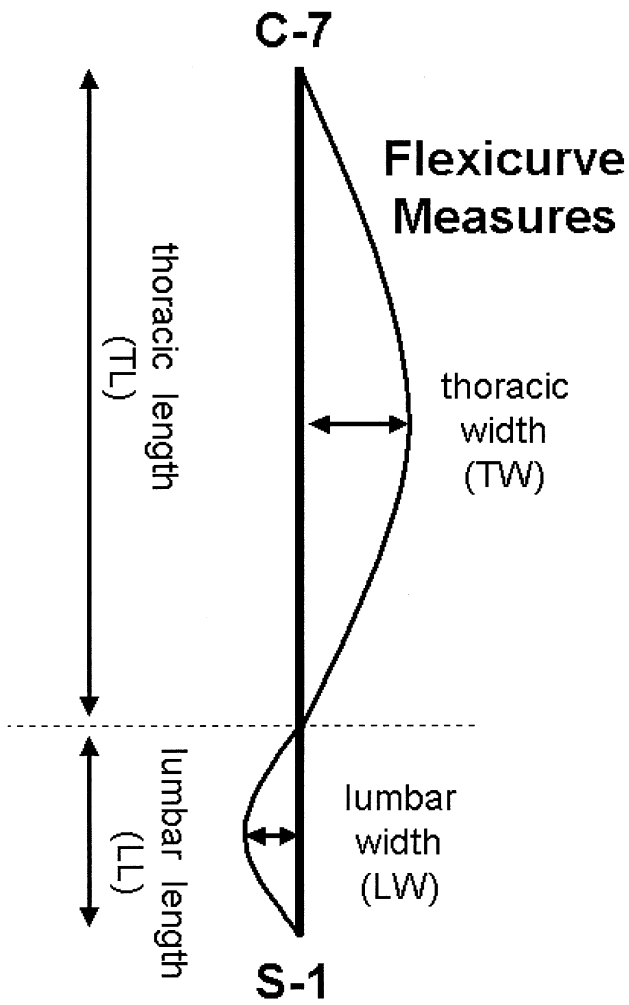

Fig. 1. Flexicurve measurement technique.

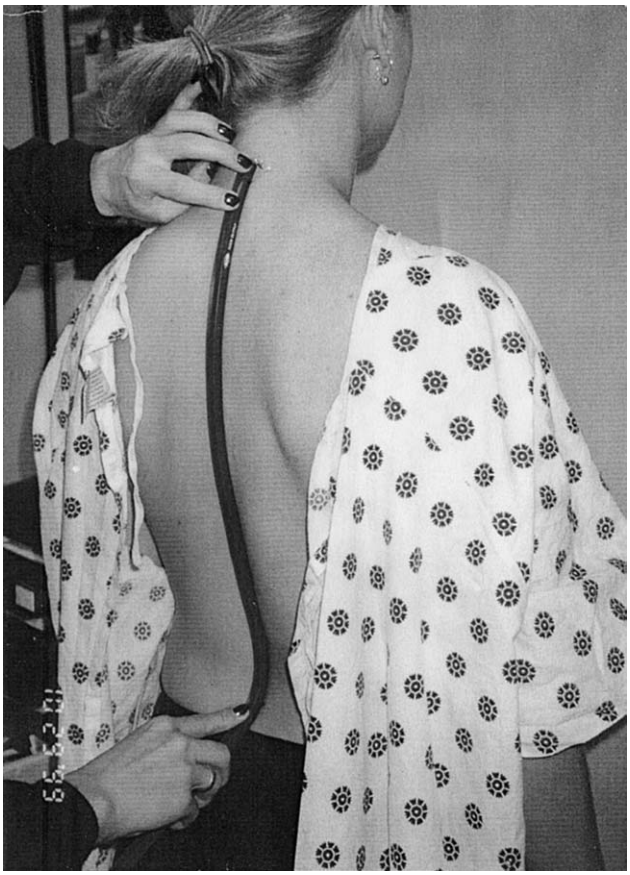

Fig. 2. Flexicurve calculation for the index of kyphosis (IK) and index of lordosis (IL): IK=TW/TL×100 IL=LW/LL×100.

(S1). The flexicurve was then placed over the spinous processes of the thoracic and lumbar spine and shaped to fit the contours of these spinal curves. The instrument was carefully removed and traced onto a piece of plain white paper. A vertical line was drawn to connect the C7 and S1 landmarks. The point where this line intersected the traced curve marked the transition between the thoracic and lumbar curves. The maximum width and the total length of the thoracic curve was measured in centimeters and used to calculate the index of kyphosis using the following formula: IK=thoracic width/thoracic length×100. Higher indexes indicate greater degrees of thoracic kyphosis and vice versa. Because the interrater reliability of the IK measures was high among the three raters (intraclass correlation coefficients [ICCs]=.94 in erect position and .93 in relaxed position), the average of these IK measures was used for data analysis.

Differences and ratios between the relaxed and erect IK measurements were then calculated. The percent change in the IK measure was determined using the following formula: $(IK_{diff}/IK_{relaxed})\times100$. An IK ratio ($IK_{relaxed}/IK_{erect}$) was also calculated to reflect the relative elasticity versus stiffness in the thoracic spine. If subjects could actively reduce their kyphosis when standing more erect, their IK ratio was greater than 1.0, indicating some degree of elasticity. Subjects who could not actively reduce their kyphosis because of stiffness had IK ratios of 1.0 or less.

Data analysis

The ranges, means, variance and correlation between IK measures in both positions were calculated for both age groups for descriptive purposes. Independent *t* tests were used to compare group differences (independent variable) in measures of kyphosis in each position, differences in the two positions, the percent of correction obtained when standing erect and the IK ratio (dependent variables). All data were analyzed at the .05 alpha level using SPSS statistical software.

Results

Significant differences were found between the younger and older women in all dependent variables (Table 1). As expected, the IK was higher for older women in both the relaxed and erect postures, indicating a greater degree of thoracic kyphosis for this age group. Normal values in the relaxed position were 12.2±3.7 and 10.0±2.4 for older and younger women, respectively. Normal values in the erect position were 11.1±3.9 and 7.2±2.2 for older and younger women, respectively. Younger women demonstrated a greater degree of active correction between the two positions, averaging 28.6% improvement in the IK compared with 9.6% in the older women. The IK ratios were above 1.0 for both age groups, although it was higher in the younger women than older women (1.5 vs 1.1). The relaxed and erect IK measures were highly correlated among all subjects (r=.93); the strength of this relationship was consistent within age groups (r=.98 for older subjects and r=.84 for younger subjects).

Table 1
Comparison of kyphosis measurements in younger (n=25) and older (n=26) women

Variable	Range	Mean	SD	*t* value	p value	Power
Relaxed IK				2.458	.018	.673
Older	7.28–21.96	12.19	3.71			
Younger	4.49–13.20	10.02	2.43			
Erect IK				4.492	<.001	.993
Older	6.40–20.89	11.11	3.86			
Younger	2.60–10.31	7.16	2.15			
IK difference				−5.845	<.001	1.000
Older	−1.00–(+)2.46	1.07	0.81			
Younger	−0.12–(+)5.26	2.86	1.33			
Percent change				−6.230	<.001	1.000
Older	−8.35–(+)25.11	9.63	7.89			
Younger	−2.09–(+)50.03	28.65	13.32			
IK ratio				−5.701	<.001	1.000
Older	0.92–1.34	1.11	0.098			
Younger	0.98–2.00	1.45	0.284			

IK=index of kyphosis.

The raters also observed a tendency for the lumbar lordosis to increase in the older women as their kyphosis decreased; however, little or no change was noted in the lumbar curvature of younger subjects. Because the lumbar measurements were less reliable among the three raters than the thoracic measurements (ICCs=.60 and .73 for relaxed vs erect), these data were not included in the analysis.

Discussion

The results supported our hypothesis that healthy older women demonstrate more postural stiffness in their thoracic spine than younger women. The IK differences and ratios indicate that most women in both age groups were able to actively reduce their kyphosis when standing in their maximally erect posture. However, younger subjects demonstrated nearly three times as much postural correction as the older subjects, which suggests an age-related difference in tissue elasticity. In a similar study, Cutler et al. [15] compared IK measures of healthy pre- and postmenopausal women that were taken in their "normal" and "upright" postures. They found significant differences in the normal IK between age groups (9.77 for premenopausal women vs 10.67 for postmenopausal women), but no age-related differences in the upright IK measures. They also reported a significant correlation between the two measures (r=.80). However, this correlation was slightly higher in the premenopausal group (r=.82) than in the postmenopausal group (r=.77). In our study, this relationship was stronger among older, postmenopausal subjects who demonstrated greater postural stiffness.

Because subjects in this study included only healthy women who had no known history of spinal pathology, these data represent normal values that may be used for comparative purposes in a clinical population. Chow and Harrison [14] found that an IK greater than 13 (taken in the erect posture) was consistent with "a clinically apparent kyphosis," whereas Cutler [15] suggests using IK thresholds of 10 or 11 (taken in a normal, relaxed posture) to classify an individual as "kyphotic." Based on Chow's criterion, 23% of the older and none of the younger women in our study had excessive kyphosis. Using Cutler's criteria, a much greater percentage of subjects in both age groups would have been classified as kyphotic (Table 2). Obviously, further studies are needed to establish the most specific and sensitive cutoff score for differentiating between normal and kyphotic curves in various age and gender groups.

Table 2
Percentage of subjects classified as kyphotic using various index of kyphosis values

	n	Relaxed IK>10	Relaxed IK>11	Erect IK>13
Total sample	51	65	51	12
Older subjects	26	73	58	23
Younger subjects	25	56	44	0

IK=index of kyphosis.

Nevertheless, clinicians could potentially use the IK ratios established in this study to help determine whether certain patients are good candidates for a postural exercise program that is primarily designed to improve the flexibility of the surrounding soft tissues. These measures could also be used to document changes in the overall stiffness of spinal muscles and connective tissues associated with a therapeutic intervention or disease progression.

Despite the significance and high power of the statistical analysis, further study is needed with a larger sample that includes men and individuals with spinal pathology to determine the generalizability of these findings to a clinical population. The ranges and variance of IK measures in the two age groups suggest that older women demonstrate greater variability in their thoracic curvature than younger women; however, younger women had more variability in their IK ratios. Data from larger samples are needed to determine whether these variances are typical. In addition, the mean body mass index (BMI) for the sample in this study was 25.1 (22.5 for the younger group; 27.7 for the older group). These BMI means are within the normal range for women in these respective age groups, indicating a lack of obesity in the overall sample. Further analysis of obese individuals is needed to determine whether the precision of these measures may be compromised when excessive soft tissues overlie the spine.

Other limitations of this study include the possibility of measurement error associated with the use of multiple raters who may have identified landmarks differently and applied varying amounts of pressure when conforming the flexicurve to the subjects' spine. Caine et al. [17] recommended attaching a strip of compact foam to the edge of the flexicurve and mounting it on a stadiometer to reduce these sources of measurement error. They also suggested an alternate geometric method for calculating the size of the spinal curvature that is probably too complex and laborious to be practical for everyday clinical use. Slight postural variations may also occur within the subjects who undergo repeated measurements, despite the precision of the protocol. However, the high reliability found among the three students who performed the measurements in this study suggests that these variations were minimal.

Conclusions

These data document age-related differences in the thoracic kyphosis of healthy women as measured by a flexicurve. Comparison of flexicurve measures taken in a relaxed and maximally erect posture were used to estimate the relative stiffness versus elasticity of the kyphotic curve. As expected, younger women demonstrated less stiffness as evidenced by a higher IK ratios and significantly greater reductions in their kyphosis when standing in the maximally erect position.

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