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Pelvic Floor Symptoms and Spinal Curvature in Women

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Abstract

Objectives—To characterize the association between thoracic (T) and lumbar (L) spinal curvature and pelvic floor (PF) symptoms (pelvic organ prolapse [POP], urinary incontinence [UI], fecal incontinence [FI]).

Methods—Of women undergoing a bone mineral density scan from 1/2007 to 10/2010, patients who completed PF symptom questionnaires and had T and/or L spine radiographs or computerized tomography (CT) exams within 3 years of questionnaire completion were included in this study. The spine angles were measured using the Cobb angle method. The T and L curvature were categorized as hypo-kyphosis (<20°), normal thoracic kyphosis (20–40°), hyper-

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I Meyer/TA McArthur/SL Morgan/JL McKinney/HE Richter: Protocol/project development, acquisition of data, data interpretation, manuscript writing/editing, final approval of the version to be published.

Y Tang: Data analysis and interpretation, manuscript writing/editing, final approval of the version to be published.

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kyphosis ($>40^\circ$), hypo-lordosis ($<40^\circ$), normal lumbar lordosis ($40\text{--}70^\circ$), and hyper-lordosis ($>70^\circ$). The presence and type of UI were identified with the 3 Incontinence Questionnaire and FI with the Modified Manchester Questionnaire. POP was defined as a positive response to the presence of a bulge question from the PF Distress Inventory-20.

Results—Of 1665 eligible women, 824 and 302 (mean age 64 ± 10 for both) had T and L spine images, respectively. No differences in PF symptoms were observed in the T or L spine groups categorized by hypo-, normal, and hyper-kyphosis/lordosis except for urgency UI being more prevalent in the hypo-lordosis group ($p=0.01$). However, upon further characterization using logistic regression, no association was noted between PF symptoms and T or L spine angles; no differences in the mean angles were found between women with versus without PF symptoms ($p=0.05$).

Conclusions—The current study shows that the thoracic and lumbar spinal curvature is not associated with the presence of pelvic floor symptoms.

Keywords

Lumbar lordosis; pelvic floor disorders; prolapse; spinal curvature; thoracic kyphosis

Introduction

Pelvic floor disorders (PFD), including pelvic organ prolapse (POP), urinary incontinence (UI), and fecal incontinence (FI), are highly prevalent conditions and significantly impact quality of life (QOL) in women.[1–7] In existing studies, the reported overall prevalence of having at least one pelvic floor symptoms was 25%, and as high as 41% reported POP symptoms in the postmenopausal population.[8–9] As the proportion of the aging population increases, these disorders become more prevalent, leading to significant social and economic burdens.

The pelvic organs are supported by pelvic floor muscles (PFM) and stabilized by connective tissues, such as ligaments and endopelvic fascia. The pelvic supporting tissues may be significantly weakened or detached from bony structures through lifestyle habits, pregnancy, childbirth, and pelvic trauma, contributing to the development of PFDs in the aging population. [1–10–14] A correlation has been shown between skeletal fragility and POP in postmenopausal women.[15–16]

The effect of spinal curvature on the pelvic structures has been theorized using a schematic vector diagram of intra-abdominal forces exerted on the pelvis, speculating that changes in spinal angles may contribute to POP development.[17] Antero-posterior shifting of the spine is commonly seen as a result of decreased bone mineral density (BMD) or advancing age. The kyphotic and lordotic deviations of the thoracic (T) and lumbar (L) spine affect the curvature in adjacent spinal regions and can cause pelvic tilt. Existing studies have suggested that the loss of normal lumbar lordosis (hypo-lordosis) or pronounced thoracic kyphosis (hyper-kyphosis) may be associated with the development of uterovaginal prolapse. However, current data regarding the potential association of abnormal spinal curvature on pelvic floor support and function are limited and exist only for POP.[18–20]

Our primary aim was to characterize an association between abnormal T and L spinal curvature, specifically thoracic hypo-/hyper-kyphosis and/or lumbar hypo-/hyper-lordosis, and pelvic floor symptoms (POP, UI, and FI) in postmenopausal women undergoing a BMD scan for osteoporosis evaluation.

Materials and Methods

This is a cross-sectional study approved by the Institutional Review Board (IRB) at the University of Alabama at Birmingham (UAB). Subjects were extracted from an IRB-approved osteoporosis and PFD database consisting of: 1) all postmenopausal women who underwent BMD assessments using a Hologic Discovery W Dual-energy X-ray absorptiometry (DXA) scanner (Bedford, MA) for osteoporosis screening at UAB from January 2007 through October 2010 and 2) who also completed and returned pelvic floor symptom questionnaires assessing the presence of pelvic floor symptoms via mail between January and February 2011. Within the database, subjects who had the following radiologic imaging studies within 3 years of their pelvic floor symptoms questionnaire completion were included in this study; patients with standing postero-anterior (PA) and lateral chest radiographs, standing antero-posterior (AP) and lateral T or L spine radiographs and/or a computer tomography (CT) of chest, abdomen, and pelvis (reformatted in the sagittal plane). In the case of multiple studies available within the defined period, the study dated closest to the date of the pelvic floor symptom questionnaire completion was selected. The angle of kyphosis was calculated using the gold standard Cobb angle method with the intersection of perpendicular lines across the superior endplate of T3 or T4 to the inferior endplate of T12 (Figure 1).[21-22] Lumbar lordosis was measured from the superior endplate of L1 and superior endplate of L5. The presence of scoliosis (defined as lateral deviation of the spine greater than 10°) [23-24] was assessed in all patients. As the reliability of the kyphosis and lordosis measurements decrease with increasing severity of scoliosis, [25] women with scoliosis were excluded from this study. The Cobb angle was measured on the lateral radiographs of the T and L spine and in the sagittal plane on the CT exams. The T spinal curvature was categorized as hypo-kyphosis (<20°), normal thoracic kyphosis (20–40°), and hyper-kyphosis (>40°), the L spinal curvature as hypo-lordosis (<40°), normal lumbar lordosis (40–70°), and hyper-lordosis (>70°) based on the current radiology literature. [26-27] The radiographic evaluation and measurements were performed by a board certified, fellowship-trained (in Musculoskeletal Imaging) radiologist who was blinded to the subjects' pelvic floor symptoms.

The presence and type of UI in the past 3 months were assessed using the 3 Incontinence Questions (3IQ). [28] Women who reported urinary leakage in the prior 3 months were classified as UI-positive. Stress urinary incontinence (SUI) was defined as an involuntary urinary leakage on exertion or on sneezing or coughing, and urgency urinary incontinence (UUI) as an involuntary leakage accompanied by or immediately preceded by urgency.[29] UI frequency was characterized utilizing the four-item International Consultation on Incontinence Questionnaire Short Form (ICIQ-SF).[30] Any FI, involuntary loss of fecal material, over the past month was qualified as FI-positive, and frequency of FI was assessed using the Modified Manchester Health Questionnaire.[31] Bothersome prolapse was defined utilizing the prolapse symptom assessment question from the Pelvic Floor Distress

Inventory-20 (PFDI-20). [32] A positive response to the question, “Do you have a bulge or something falling out that you can see or feel in your vaginal area?” was defined as POP-positive.

Demographic information was collected from the database including age, race, body mass index, the number of vaginal deliveries, prior surgery for incontinence and/or POP, and other potential risk factors for PFDs such as estrogen hormone replacement therapy, use of BMD medications or steroids, smoking, alcohol use, and history of chronic obstructive pulmonary disease (COPD), and BMD scores from the DXA scan.

Descriptive statistics were used to describe subjects' demographic characteristics. Outcomes were examined across three groups using χ^2 test for categorical measures and one-way analysis of variance (ANOVA) for continuous measures. When distributional assumptions for these methods were not met, Pearson's exact test and Kruskal-Wallis test were used. For two group comparisons, χ^2 test and Fisher's exact test were used for categorical measures as appropriate. Two sample t-test and Wilcoxon rank-sum test were used for continuous measures. Logistic regression models controlling for age, race, BMD medication use, steroid use, tobacco use, and COPD were performed to assess the association between the symptoms and changes in T and L angles. P-values of <0.05 were considered statistically significant. Statistical analysis was conducted using SAS version 9.3 (SAS Institute, Inc., Cary, NC).

Results

Of the 1665 eligible women extracted from the existing IRB-approved database, T and L spine images were available for 824 and 302 women, respectively. Of these subjects, 214 had both T and L images. The overall mean age was 64 ± 10 years. The racial distribution was 74% Caucasian, 22% African American, and 4% other. Of the subjects, 21% had osteoporosis, 51% had osteopenia, and 28% had normal BMD. Standing radiographs were available in most subjects. CT images were used only in 1.5% of the subjects to evaluate their spinal curvature. Overall prevalence of having any pelvic floor symptoms was 82% (992/1126), POP 10% (115/1126), and any UI (in the last 3 months) 75% (847/1126). Of 847 women with UI-positive, the majority (60%, 511/847) had frequency of UI 2–3 times/week. Any FI (in the past month) was seen in 31 % (352/1126). Of 352 women with FI-positive, the majority (64%, 226/352) had frequency of FI at least once a week (Table 2).

For the 3-group comparison based on the T curvature categories, 25 women had hypo-kyphosis, 402 had normal T curvature, and 397 had hyper-kyphosis. Significant demographic differences were noted in age ($p<0.001$), race ($p<0.001$), the use of BMD medication ($p<0.001$), steroid use ($p=0.01$), smoking ($p=0.04$), COPD ($p=0.006$) and the mean BMD scores ($p<0.001$, Table 1). No significant difference in any of the pelvic floor symptoms (UI, FI, or POP) were found among the T curvature categories ($p \geq 0.05$, Table 2).

For the L curvature types, 153 women had hypo-lordosis and 149 had normal L curvature. Their baseline demographics differed in the number of vaginal deliveries ($p=0.04$), steroid use ($p=0.01$), and mean BMD scores ($p=0.03$, Table 1). No significant differences in any of

the pelvic floor symptoms were observed between the hypo-lordosis and normal curvature groups except for urgency UI being more prevalent in the hypo-lordosis group ($p=0.01$, Table 2).

We further characterized how the changes in T and L spinal angles affect having pelvic floor symptoms using logistic regression. No association was observed between having pelvic floor symptoms (any symptoms, UI, FI, POP) and T or L spine angles (Table 3). The mean angles of T and L spines did not differ between women with versus without pelvic floor symptoms (Table 3).

Of the study population, 128 of 824 (16%) and 48 of 302 (16%) women had prior incontinence and/or prolapse surgeries in the T and L spine groups, respectively ($p=0.57$ and 0.68 , Table 1). However, the results did not change significantly upon excluding women with prior surgery from the data analysis; no significant difference in any of the pelvic floor symptoms among the T-spinal curvature types, the hypo-lordosis group still having a higher rate of urgency UI ($p=0.01$), and no significant association between having pelvic floor symptoms and T or L spine angles.

Discussion

This study with a robust sample size demonstrated that T and L spinal angles were not significantly associated with pelvic floor symptoms (POP, UI, or FI) in postmenopausal women undergoing a bone mineral density scan for osteoporosis evaluation. The overall prevalence of UI (75%) in this study was higher compared to existing population based studies.[1·2·4·6·8·9] First, we classified women reporting urinary leakage of any type in the prior 3 months as UI-positive, which likely attributed to the inflation of the overall rate. In addition, the mean age in this study was 64 years, which may also be a reason for the higher rate compared to that of general population, as age is a significant risk factor for UI. However, when comparing the frequency and severity of UI, our study found 29% (321/1126) with UI once a week, 45% (511/1126) with 2–3 times/week, which is compatible to a recent population based study with the rate of moderate to severe UI of 25–38% in women older than 60 years of age.[8]

Historically, the role of spinal curvature on the pelvic floor structures was theorized using a schematic vector diagram proposing that the orientation of the spinal curvature and pelvic inlet acts as a buffer to absorb downward abdominal forces toward the pelvis. Thus it has been speculated that the changes in spinal curvature may contribute to POP development.[17] Most existing studies describe the association of pelvic floor structures and spinal curvature in the setting of changing postures.[34–37] Capson et al. reported that postural changes in standing (i.e. bending) could alter pelvic floor muscle activity.[34]

A small number of studies have explored the association between abnormal spinal curvature and POP. Lind et al. retrospectively assessed the relationship between thoracic kyphosis and uterine prolapse (48 women with advanced prolapse versus matched controls, both undergoing hysterectomy).[18] The authors found that the uterine prolapse group had a higher kyphotic angle with the difference of 4.9° and odds ratio of 1.35 (95% CI 1.11–1.65).

However, the authors noted the difference in the mean angles was small, thus clinical significance remains unclear.

Mattox et al. reported that loss of lumbar lordosis was associated with POP.[20] In their study, the type of T and L spinal curvature (normal versus abnormal) was defined by an alternative method using a semi-flexible rod instead of radiographic evaluation of the entire spinal column. Subjects were those who presented with “complaints of urinary incontinence or pelvic organ prolapse”, therefore generalization is limited.

Nyugen et al. reported that the mean lumbar angle was 10° lower in the prolapse group compared to the controls. However their study was limited by a small sample size (20 per group), not meeting their sample size estimation (22 in each group to detect a 15° difference). In addition, the results may not be generalizable as the samples were recruited from a gynecology clinic with a skewed racial distribution (65% Hispanics).[19]

The current study is limited by its retrospective design to identify eligible subjects, thus we were unable to determine causation between spinal curvature and development of pelvic floor symptoms. The radiologic images (plane films or CT scans) to analyze spinal curvature were of those performed within three years of questionnaire completion. The time lag between the assessment of spinal curvature and pelvic floor symptoms may have potentially resulted in recall bias. The current study included only the subjects whose spine radiologic images were available, thus potentially leading to selection bias. However, the thoracic and lumbar curvature images were available for 824 and 302 subjects, respectively, which is the largest sample size reported in the current literature. The racial distribution of this study is similar to that of the national demographics reported by the United States (US) Census Bureau in 2010.[38] The rate of osteoporosis was 21% in this study, comparable to 16% among women 50 years of age or older in the US.[39] The association between pelvic floor symptoms in postmenopausal women and bone mineral density has been previously reported.[1]

In regard to the radiographic evaluation, the entire images were examined by a single musculoskeletal radiologist. However, high reproducibility and reliability of Cobb angle measurements has been described in the current literature.[40] In order to reduce potential bias, the radiologist was blinded to subjects’ pelvic floor symptoms and demographic information. The T and L spine radiographs were measured in the standing position, whereas the CT images were measured in the sagittal plane with the patient supine. However, standing radiographs were available in almost all (98.5%) of the subjects. Although it is possible that the non-standing position may have underestimated the true spinal curvature measurement slightly in these patients, it is unlikely that the imaging modalities had a significant influence on the outcomes of the study.

The strengths of this study include that we characterized pelvic floor symptoms using validated measures and examined the association of all three types of pelvic floor symptoms (POP, UI, and FI) with both thoracic and lumbar spinal curvature. Subjective symptoms have been shown to correlate with the presence of pelvic floor disorders based on objective findings. [41-42] In addition, we aimed to represent a broader population compared to other

previous studies. Subjects were those who had undergone a BMD scan for osteoporosis screening with the rate of osteoporosis in this study comparable to that of the general population.

In conclusion, the current study showed no significant association of pelvic floor symptoms with thoracic or lumbar spinal curvature. Compared to the abundant data on the association of pelvic floor disorders with weakened striated muscles, smooth musculo-connective tissue, neuromuscular and ligamentous pelvic support structures, data on the association between bony spinal curvature and pelvic floor symptoms have been lacking. Further prospective studies may be warranted to understand the effect of bony changes in spinal curvature on female pelvic floor function. Specifically, future areas of exploration should include examining the association of pelvic tilt, pelvic incidence, and sacral slope and their related impact on the bony pelvic outlet on pelvic floor symptomatology.

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Figure 1. Standing lateral thoracic spine radiograph demonstrates the Cobb angle method by drawing lines parallel to the superior endplate of T3 or T4 and the inferior endplate of T12 and measuring the angle formed by the intersection of the two lines.

Table 1

Demographics by Thoracic and Lumbar Curvature Status

Characteristic	Thoracic Curvature					Lumbar Curvature				
	Overall (n=824)	Hypo-K (n=25)	Normal.T (n=402)	Hyper-K (n=397)	p	Overall (n=302)	Hypo-L (n=153)	Normal.L (n=149)	Hyper-L (n=0)	P
Age (years) *	64.1 ± 10.0	60.6 ± 9.4	61.8 ± 9.5	66.6 ± 10.0	<0.0001	63.7 ± 9.7	63.8 ± 9.6	63.5 ± 9.9		0.83
Race †					0.0005					0.86
White	607 (74%)	14 (56%)	275 (68%)	318 (80%)		228 (76%)	115 (75%)	113 (76%)		
Black	184 (22%)	10 (40%)	110 (27%)	64 (16%)		62 (21%)	31 (20%)	31 (21%)		
Other	33 (4 %)	1 (4%)	17 (4%)	15 (4%)		12 (4%)	7 (5%)	5 (3%)		
BMI †					0.64					0.70
Normal	349 (42%)	9 (36%)	168 (42%)	172 (43%)		129 (43%)	65 (43%)	64 (43%)		
Overweight	246 (30%)	8 (32%)	114 (28%)	124 (31%)		83 (28%)	45 (29%)	38 (26%)		
Obese	229 (28%)	8 (32%)	120 (30%)	101 (25%)		90 (30%)	43 (28%)	47 (32%)		
Vaginal delivery †					0.82					0.04
0	175 (23%)	7 (30.4%)	89 (24%)	79 (21%)		61 (22%)	31 (22%)	30 (22%)		
1	120 (16%)	3 (13.4%)	60 (16%)	57 (16%)		53 (19%)	19 (13%)	34 (25%)		
2	472 (62%)	13 (57%)	226 (60%)	233 (63%)		166 (59%)	93 (65%)	73 (53%)		
Prior UI/POP surgery †	128 (16%)	2 (8%)	64 (15%)	62 (15.6%)	0.57	48 (16%)	23 (15%)	25 (17%)		0.68
BMD medication †	225 (27%)	9 (36%)	85 (21%)	131 (33%)	0.0005	93 (31%)	47 (31%)	46 (31%)		0.98
Steroid Use †	66 (8%)	6 (24%)	31 (7%)	29 (7%)	0.011	23 (8%)	6 (4%)	17 (11%)		0.01
Tobacco Use †	64 (8%)	1 (4%)	41 (10%)	22 (6%)	0.038	28 (9%)	11 (7%)	17 (11%)		0.21
Alcohol Use †	10 (1%)	0 (0%)	6 (2%)	4 (1%)	0.82	4 (1%)	1 (1%)	3 (2%)		0.37
Hormone Use †	147 (19%)	2 (8%)	82 (22%)	63 (17%)	0.12	63 (22%)	32 (23%)	31 (22%)		0.84

	Thoracic Curvature					Lumbar Curvature				
Characteristic	Overall (n=824)	Hypo-K (n=25)	Normal T (n=402)	Hyper-K (n=397)	p	Overall (n=302)	Hypo-L (n=153)	Normal L (n=149)	Hyper-L (n=0)	P
COPD [†]	35 (4%)	1 (4%)	8 (2%)	26 (7%)	0.006	12 (4%)	6 (4%)	6 (4%)		0.96
BMD T score [*]	-1.6 ± 1.1	-1.2 ± 1.4	-1.4 ± 1.1	-1.8 ± 1.0	<0.0001	-1.6 ± 1.1	-1.5 ± 1.1	-1.8 ± 1.1		0.03

^{*} mean ± standard deviation;

[†] number (%);

BMI: body mass index; UI: urinary incontinence; POP: pelvic organ prolapse; BMD: body mineral density; COPD: chronic obstructive pulmonary disease; K: kyphosis; T: thoracic; L: lordosis or lumbar

Table 2

Pelvic Floor Symptoms by Thoracic and Lumbar Curvature Status

	Overall	Thoracic Curvature				Lumbar Curvature			
	n=1126	Hypo-K n=25	Normal T n=402	Hyper-K n=397	P	Hypo- L n=153	Normal L n=149	Hyper-L n=0	P
Any symptoms	922 (82%)	20 (91%)	318 (81%)	330 (86%)	0.09	126 (88%)	128 (86%)		0.97
Any UI	847 (75%)	18 (75%)	290 (73%)	306 (78%)	0.29	118 (78%)	115 (77%)		0.93
Stress [*]	573 (68%)	13 (72%)	193 (67%)	209 (68%)	0.82	82 (70%)	76 (66%)		0.58
Urgency [*]	636 (75%)	13 (72%)	220 (76%)	237 (78%)	0.82	93 (79%)	73 (64%)		0.01
Frequency of UI [*]					0.50				0.93
1/week	321 (38%)	9 (50%)	108 (38%)	109 (37%)		48 (41%)	47 (41%)		
2–3/week	511 (60%)	9 (50%)	175 (62%)	190 (64%)		70 (59%)	67 (59%)		
FI	352 (31%)	8 (35%)	119 (32%)	126 (35%)	0.68	51 (37%)	48 (36%)		0.81
Frequency of FI [†]					0.34				0.16
1–3/mo	126 (36%)	1 (13%)	40 (34%)	47 (37%)		23 (45%)	15 (31%)		
>1/wk	226 (64%)	7 (88%)	79 (66%)	79 (63%)		28 (55%)	33 (69%)		
POP	115 (10%)	3 (13%)	39 (10%)	40 (11%)	0.91	14 (10%)	19 (14%)		0.29

^{*} rates among women having any UI (n=847);[†] rates among women having FI (n=352)

UI: urinary incontinence; FI: fecal incontinence; POP: pelvic organ prolapse

Table 3

Mean Thoracic and Lumbar Spine Angles With Versus Without Pelvic Floor Symptoms

	Thoracic Spine Angles			Lumbar Spine Angles		
	Symptoms		P [*]	Symptoms		P ^{**}
	YES Mean ± SD	NO Mean ± SD		YES Mean ± SD	NO Mean ± SD	
Any symptoms	40.8 ± 13.0	38.4 ± 11.8	1.01 (0.99–1.03)	39.1 ± 12.2	39.8 ± 10.1	1.00 (0.96–1.03)
Any UI	40.9 ± 13.0	39.1 ± 12.4	0.99 (0.98–1.01)	38.9 ± 12.3	39.4 ± 11.3	1.01 (0.98–1.03)
Stress	40.5 ± 12.5	41.7 ± 13.9	0.99 (0.98–1.01)	39.1 ± 12.0	38.5 ± 12.9	1.00 (0.98–1.02)
Urgency	41.0 ± 13.0	40.6 ± 13.1	1.00 (0.99–1.02)	38.5 ± 12.2	39.9 ± 12.5	1.00 (0.97–1.02)
FI	41.0 ± 12.5	39.9 ± 13.0	1.00 (0.99–1.02)	37.9 ± 11.9	39.8 ± 11.9	0.98 (0.96–1.00)
POP	39.6 ± 13.1	40.4 ± 12.9	0.99 (0.97–1.01)	39.4 ± 12.6	39.0 ± 12.1	1.01 (0.97–1.04)

SD: standard deviation; UI: urinary incontinence; FI: fecal incontinence; POP: pelvic organ prolapse

^{*} Adjusted for age, race, BMD medication, steroid use, tobacco use and COPD^{**} Adjusted for vaginal delivery and steroid use