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Relationships between sacral, lumbar and thoracic spine position and trunk mobility in the sagittal plane in young adults

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Original article

Abstract

Aim of the study: The aim of the study was to assess the relationship between the position of the sacrum, lumbar and thoracic spine and the mobility of the trunk in the sagittal plane in young women and men.

Material and methods: 64 students (33 women and 31 men) were studied. The mean age in the study group was 22.94 ± 1.51 years. The following tests were performed on each subject once: measurement of height and weight, assessment of spinal alignment and mobility in the sagittal plane using Zebris Pointer.

Results: The results obtained were analyzed using appropriate statistical tools. Statistically significant correlations were obtained: in the alignment of the sacrum in relation to the lumbar spine (strong correlation), in the alignment of the lumbar spine in relation to the thoracic spine and, in the male group only, between the alignment of the thoracic spine and mobility in the direction of flexion in the thoracic segment (moderate correlation).

Conclusions: In women, horizontal sacral alignment coexisting with deepened lordosis was most frequently observed. In addition, women were more likely to have a deepened thoracic kyphosis, less range of motion in the direction of thoracic flexion and extension, and greater mobility in the direction of lumbar flexion and extension than men. In men, the vertical alignment of the sacrum was accompanied by a shallowing of the physiological lordosis. In addition, in this group, a decrease in lordosis influenced an increase in movement to flexion in the thoracic spine. When planning a physiotherapy exercise program for a person in whom abnormalities in the alignment of the lumbopelvic complex have been noted, an individual exercise program should be selected. The study should take into account not only the evaluation of the alignment of the lumbosacral spine, but also the mobility of the segments above and below the examined area taking into account intergender differences.

Keywords

- spinal curvatures
- sagittal plane
- sacral position
- spinal mobility

Contribution

A – the preparation of the research project
B – the assembly of data for the research undertaken
C – the conducting of statistical analysis
D – interpretation of results
E – manuscript preparation
F – literature review
G – revising the manuscript

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Introduction

The adoption by man of an upright position with a highly localized center of gravity was associated with the emergence of a number of changes in posture. These included: the release of the hands from support functions, the development of spinal arches, the development of foot arches, and differences in the structure of the human pelvis.[1] Some researchers have noted the connections that exist between the position of the lumbar spine, pelvis and hip joints. They point out that the pelvis is a key component of this complex, as any dysfunction within it can affect postural worsening and possibly be the cause of reported pain.[2] In the female pelvis, the hip bones are strongly laterally spaced, while in men they point more steeply. The pubic symphysis in women is lower and the subpubicus angle is greater, and the distance between the ischial tuberosities is also greater. The sacrum is relatively wider and flatter in women than in men. The position of the sacrum, which is one of the elements of the pelvis, can affect the position of the lumbar spine and this in turn affects the alignment of the thoracic spine. The female pelvis, being different in its structure from the male pelvis, may be the cause of inter-gender variation in the alignment and mobility of the spine.[1,3] Maintaining proper mobility within a given motor segment and proper movement timings may affect the reduced risk of the appearance of musculoskeletal pain.[4,5]

The literature and clinical experience report that the most objective way to assess spinal position is by x-ray (X-ray), which accurately depicts the symmetry and posision of the sacrum, or the size of the lumbar lordosis. However, due to exposure to harmful ionizing radiation, scientific research and everyday physiotherapy practice uses such devices and instruments as inclinometer, plurimeter, Zebris Pointer, Medi Mouse, among others. The latter two show high convergence of results with X-ray examination.[6,7,8]

Aim of the study

The study presents the relationship between the position of the sacrum, lumbar spine, thoracic spine and the mobility of the trunk in the sagittal plane taking into account sexual dimorphism

Material and methods

The study included 64 students of the Faculty of Health Care (33 women, 31 men) of the Academy of Applied Sciences in Tarnow. The average age in the study group was 22.94 ± 1.51 years. All participants were informed in detail about the course of the study and signed an informed consent to participate. The study was conducted with high scientific and ethical standards. Inclusion criteria for the study were: age 20–31 years, male and female, willingness to participate in the study, absence of any injury in the last two weeks. Exclusion criteria were: fresh injury (injury occurred no more than two weeks before entering the study), pregnancy, and lack of consent to participate in the study.

Body height was assessed using an anthropometer (ZPH Alumet No 010208, Warsaw, Poland) from the Basis point to the Vertex point with an accuracy of 0.01 m. A Tanita scale (body composition analyzer bf-350; Tanita Corporation of America, Inc., Arlington Heights, Illinois) was used to assess body weight with an accuracy of 0.1 kg. Based on the aforementioned data, BMI was determined, assuming that BMI ≥25 kg/m^2 indicates overweight and BMI ≥30 kg/m^2 indicates obesity.

An ultrasonic Zebris Pointer with WinSpine software (ZebrisMedical GmbH Company, Germany) was used to assess the position and mobility of the spine in the sagittal plane, the reliability of which was confirmed by tests.[8,9] The measuring station consisted of a measuring sensor with a stand, a system of micro transmitters and an ultrasonic point indicator, which redirected the results to a computer in real time and compiled them into a report. Each of the respondents entered the study without shoes, in sports clothes, without any ornaments in their hair, with their eyes directed straight ahead. The examination was conducted in an upright, uncorrected position (habitual position). The examined person had his back to the receiver, which was set at a distance of about 80 cm. The receiver was positioned at an angle of 70 degrees to the ground. Before starting the actual test, the device was calibrated by marking four points forming a square with sides of approx. 25 cm. Then, the actual examination was started by indicating certain points on the patient's body with the use of a point index. They were: left / right acromion, left / right anterior superior iliac spine, left / right posterior superior iliac spine, top of the iliac crest, Th12 / L1 point, left / right inferior angle of the scapula, spine line from C7 to S3. The position of the spine was assessed 3 times and then averaged by the program. A virtual plane is created by means of the introduced points of the posterior superior iliac spines and the first point of the C7 spinal line of the spine. These planes form the projection areas of the calculated angles along the spinal line of the spinal processes. Introducing the Th12 / L1 point divides the assessed position of the spine into the thoracic and lumbar spine. The kyphosis angles of the thoracic spine and the lordosis of the lumbar spine are calculated by the software from the sum of the angles of the tangents. The calculations were made by summing the values of the individual angles. The angle of the sacral segment is determined with reference to the frontal plane (Figure 1).

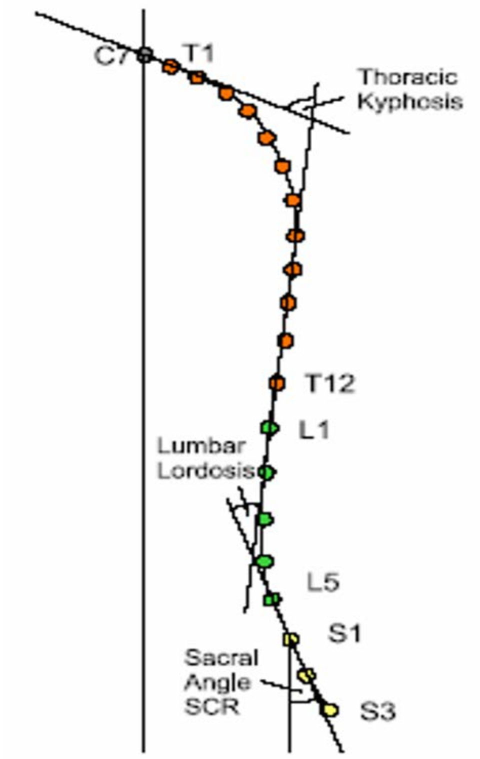

Figure 1. How to determine the size of spinal curvatures in the sagittal plane

Source: WinSpine 2.x for Windows User Manual: Determining the posture, shape and mobility of the spine using a point indicator

For the purposes of this publication, due to the large volume of data, only the data describing the position of the spine in the sagittal plane were used. The normative data provided by the manufacturer was used to assess the physiological curvatures of the spine and mobility. The obtained values were given in degrees where the correct value of thoracic kyphosis for women was 21°–32° and for men 33°–43°. The normal value of lumbar lordosis for women and men was 28°–34° and 22°–28°, respectively. On the other hand, the correct position of the sacrum was assumed to be 18°–27° in women and 12°–19° in men.

The mobility of the spine in the direction of flexion and extension was then assessed. The subject performed trunk flexion from a standing position and the examiner marked the line of the spine in the position of maximum flexion. This was followed by a test in the direction of straightening, where the subject was asked to straighten the trunk from a standing position and the examiner marked the line of the spine in the position of maximum straightening using a pointer. Normative values determined by the manufacturer were used in the evaluation of spinal mobility. The normal mobility of the thoracic spine in the direction of flexion for both men and women was taken as a mixed value in the range of 8°–22°, while for the lumbar spine 40°–70°.

Results

The body height, body weight and BMI of the male subjects were significantly higher than those of the female subjects (Table 1).

Table 1. Basic somatic features of the participants

Variable	Sex	$\bar{x}$	Me	Min	Max	Qr	SD	p
Body height [cm]	W	165.38	165.00	154.50	178.00	10.00	6.10	<0.0001*
	M	180.84	180.00	169.00	193.00	9.00	6.62	
Body weight [kg]	W	62.96	59.90	48.10	131.00	10.50	13.63	<0.0001*
	M	83.78	84.30	59.60	102.80	19.20	11.61	
BMI [kg/m^2]	W	23.00	22.31	17.67	43.77	2.83	4.47	<0.0001*
	M	25.55	25.63	18.60	31.38	3.13	2.76	

* – statistically significant difference; $\bar{x}$ – mean; Me – median; Min – minimum; Max – maximum; Qr – quartile range; SD – standard deviation; W – women; M – men

Table 2. The position of the spine in the sagittal plane

Variable	Sex	$\bar{x}$	Me	Min	Max	Qr	SD	*p*
Thoracic kyphosis [°]	W	37.88	39.90	13.00	58.00	13.30	12.00	0.217
	M	34.05	34.70	6.00	62.70	19.70	12.63	
Lumbar lordosis [°]	W	32.51	33.60	9.80	50.00	15.40	10.64	<0.0001*
	M	19.57	19.40	0.00	34.90	12.80	9.37	
Sacral angle [°]	W	24.93	25.50	6.40	43.70	10.50	8.34	<0.0001*
	M	14.46	14.60	1.60	32.00	10.40	6.98	

* – statistically significant difference; $\bar{x}$ - mean; Me – median; Min – minimum; Max – maximum; Qr – quartile range; SD – standard deviation; W – women; M – men

The women studied had higher kyphosis values compared to men. However, these differences were not significant. The depth of lumbar lordosis and sacral position in the women were statistically significantly different than in the male subjects (Table 2).

Round kyphosis was noted in more than two-thirds of the women studied, while 41.94% of the men had flat kyphosis. Round lordosis was noted in almost half of the women studied (45.45%). However, 2/3 of the male subjects were characterized by flat lordosis. A horizontal position of the sacrum was noted in just over 1/3 of the women studied. In contrast, vertical sacral bone position was noted in men (35.48%) (Table 3).

Table 3. Position of the spine in the sagittal plane – qualitative data [n]

Variable	Sex	Flat	Normal	Round
Thoracic kyphosis	W	4 (12.12%)	6 (18.18%)	23 (69.70%)
	M	13 (41.94%)	10 (32.26%)	8 (25.81%)
Lumbar lordosis	W	10 (30.30%)	8 (24.24%)	15 (45.45%)
	M	20 (64.52%)	7 (22.58%)	4 (12.90%)
Variable	**Sex**	**Vertical**	**Normal**	**Horizontal**
Sacral position	W	6 (18.18%)	15 (45.45%)	12 (36.36%)
	M	11 (35.48%)	13 (41.94%)	7 (22.58%)

In women, horizontal alignment of the sacrum was most often observed with round lordosis (1/3 of the subjects). In men, vertical alignment of the sacrum was most often observed with flat lordosis (almost 1/3 of the subjects) (Table 4).

Table 4. Relationships between the position of the sacrum and the position of the lumbar spine in women and men – qualitative data

Sacrum position	Sex	Flat lordosis	Normal lordosis	Round lordosis
Vertical	W	6 (100.00%)	0 (0.00%)	0 (0.00%)
	M	11 (100.00%)	0 (0.00%)	0 (0.00%)
Normal	W	4 (26.67%)	7 46.67%)	4 (26.67%)
	M	9 (69.23%)	2 (15.38%)	2 (15.38%)
Horizontal	W	0 (0.00%)	1 (8.33%)	11 (91.67%)
	M	0 (0.00%)	5 (71.43%)	2 (28.57%)

The horizontal position of the sacrum most often coexisted with round thoracic kyphosis (1/3 of the women studied) (Table 5).

Table 5. Relationships between the position of the sacrum and the position of the thoracic spine in women and men – qualitative data

Sacrum position	Sex	Flat kyphosis	Normal kyphosis	Round kyphosis
Vertical	W	2 (33.33%)	2 (33.33%)	2 (33.33%)
	M	4 (36.36%)	5 (45.45%)	2 (18.18%)
Normal	W	1 6.67%)	4 (26.67%)	10 (66.67%)
	M	7 (53.85%)	2 (15.38%)	4 (30.77%)
Horizontal	W	1 (8.33%)	0 (0.00%)	11 (91.67%)
	M	2 (28.57%)	3 (42.86%)	2 (28.57%)

More than 1/3 of the female subjects were characterized by the presence of a round lumbar lordosis with a round thoracic kyphosis. In the group of men, flat lumbar lordosis was most often associated with flat thoracic kyphosis (1/3 of the subjects) (Table 6).

Table 6. Lumbar spine position and thoracic spine position

Lumbar lordosis	Sex	Flat kyphosis	Normal kyphosis	Round kyphosis
Flat	W	3 (30.00%)	3 (30.00%)	4 (40.00%)
	M	11 (55.00%)	6 (30.00%)	3 (15.00%)
Normal	W	0 (0.00%)	2 (25.00%)	6 (75.00%)
	M	1 (14.29%)	3 (42.86%)	3 (42.86%)
Round	W	1 (6.67%)	1 6.67%)	13 (86.67%)
	M	1 (25.00%)	1 (25.00%)	2 (50.00%)

Significant correlations between sacrum position and lumbar spine position (Pearson correlation) were noted in both men and women (Table 7).

Table 7. Relationships between sacral and lumbar spine in men and women

Women			Lumbar lordosis vs Sacrum	Men		
R^2	P	R		R	P	R^2
0.76	<0.01*	0.89		0.82	<0.01*	0.68

* – statistically significant difference

Significant correlations between the position of the lumbar and thoracic spine (Pearson's correlation) were noted in both the male and female groups (Table 8).

Table 8. Relationships between lumbar spine and thoracic spine alignment in men and women

Women			Lumbar lordosis vs Thoracic kyphosis	Men		
R^2	P	R		R	P	R^2
0,23	<0.01*	0.48		0.48	0.01*	0,23

* – statistically significant difference

Women had statistically significantly lower mobility in the direction of flexion in the thoracic spine and higher mobility in the direction of extension in the lumbar spine compared to men (Table 9).

Only in the male group were significant correlations observed between the position of the thoracic spine and the range of thoracic flexion. The lower the thoracic kyphosis values were, the more flexion the subjects performed (Table 10).

Due to the lack of normative data for extension motion in the thoracic spine and lumbar spine, qualitative data are presented below only for flexion motion.

Slightly more than 3/5 of the female and almost 90% of the male subjects were characterized by increased mobility in the direction of flexion in the thoracic spine. Normal mobility in the direction of lumbar flexion was observed in 3/4 of the women and more than 80% of the men studied (Table 11).

Table 9. Spine mobility in the sagittal plane

Variable	Sex	$\bar{x}$	Me	Min	Max	Qr	SD	*p*
Thoracic spine-flexion [°]	W	24.28	25.70	−1.90	50.00	13.80	11.84	0.001*
	M	32.59	33.40	13.40	49.30	7.00	8.04	
Thoracic spine-extension[°]	W	9.92	7.80	−24.20	41.90	20.50	14.51	0.06
	M	16.16	15.60	−2.20	47.70	13.40	11.15	
Lumbar spine-flexion [°]	W	50.52	50.80	22.70	72.60	12.10	11.59	0.371
	M	47.89	47.50	13.10	65.20	12.20	11.76	
Lumbar spine-flexion [°]	W	17.87	20.00	−1.30	38.50	13.00	9.97	0.008*
	M	11.93	10.70	2.30	28.70	9.50	7.10	

* – statistically significant difference; $\bar{x}$ – mean; Me – median; Min – minimum; Max – maximum; Qr – quartile range; SD – standard deviation; W – women; M – men

Table 10. Relationships between the position of the sacrum, lumbar spine, thoracic spine and the mobility of the spine towards flexion in women and men

Women			Correlations between the variables	Men		
R^2	P	R		R	P	R^2
0.03	0.36	−0.16	Sacrum angle vs mobility in the thoracic spine towards flexion	0.09	0.62	0.01
0.04	0.25	0.20	Sacrum angle vs mobility in the lumbar spine towards flexion	0.05	0.78	0.00
0.02	0.41	−0.15	Position of the lumbar lordosis vs mobility in the thoracic spine towards flexion	−0.30	0.10	0.09
0.05	0.19	0.23	Position of the lumbar lordosis vs mobility in the lumbar spine towards flexion	−0.05	0.79	0.00
0.00	0.99	0.00	Position of the thoracic kyphosis vs mobility in the thoracic spine towards flexion	−0.45	0.01*	0.20
0.06	0.15	0.25	Position of the thoracic kyphosis vs mobility in the lumbar spine towards flexion	−0.18	0.34	0.03

* – statistically significant difference

Table 11. Mobility towards flexion in the thoracic and lumbar spine – qualitative data

Variable	Sex	Mobility decreased	Mobility normal	Mobility increased
Thoracic kyphosis	W	9 (9.09%)	10 (30.30%)	20 (60.61%)
	M	0 (0.00%)	4 (12.90%)	27 (87.10%)
Lumbar lordosis	W	7 (21.21%)	25 (75.76%)	1 (3.03%)
	M	5 (16.13%)	26 (83.87%)	0 (0.00%)

In both men and women, the most commonly observed flexion pattern of the entire spine was normal lumbar mobility and increased thoracic mobility (42% of women, 77% of men) (Table 12).

Table 12. Mobility in the direction of flexion in the thoracic and lumbar spine in a group of men and women – qualitative data

Variable	Sex	Mobility decreased (Th)	Mobility normal (Th)	Mobility increased (Th)
Mobility decreased (L)	W	1 (14.29%)	1 (14.29%)	5 (71.43%)
	M	0 (0.00%)	2 (40.00%)	3 (60.00%)
Mobility normal (L)	W	2 (8.00%)	9 (36.00%)	14 (56.00%)
	M	0 (0.00%)	2 (7.69%)	24 (92.31%)
Mobility increased (L)	W	0 (0.00%)	0 (0.00%)	1 (100.00%)
	M	0 (0.00%)	0 (0.00%)	0 (0.00%)

Almost 60% of male subjects with flat lumbar lordosis had normal mobility to flexion in the lumbar spine and increased mobility to flexion in the thoracic spine. In the female group, on the other hand, normal mobility to flexion in the lumbar spine was most often observed among subjects with round lordosis (more than 1/3 of the subjects) (Tables 13, 14).

Table 13. Lumbar spine position vs lumbar flexion mobility

Lumbar lordosis	Sex	Mobility decreased (L)	Mobility normal (L)	Mobility increased (L)
Flat	W	2 (20.00%)	8 (80.00%)	0 (0.00%)
	M	2 (10.00%)	18 (90.00%)	0 (0.00%)
Normal	W	3 (37.50%)	5 (62.50%)	0 (0.00%)
	M	1 (14.29%)	6 (85.71%)	0 (0.00%)
Round	W	2 (13.13%)	12 (80.00%)	1 (6.67%)
	M	2 (50.00%)	2 (50.00%)	0 (0.00%)

Table 14. Lumbar spine position vs thoracic flexion mobility

Lumbar lordosis	Sex	Mobility decreased (Th)	Mobility normal (Th)	Mobility increased (Th)
Flat	W	2 (20.00%)	0 (0.00%)	8 (80.00%)
	M	0 (0.00%)	2 (10.00%)	18 (90.00%)
Normal	W	1 (12.50%)	3 (37.50%)	4 (50.00%)
	M	0 (0.00%)	0 (0.00%)	7 (100.00%)
Round	W	0 (0.00%)	7 (46.67%)	8 (53.33%)
	M	0 (0.00%)	2 (50.00%)	2 (50.00%)

One-third of the men who had a flat thoracic kyphosis and half of the women who had a round kyphosis were characterized by normal lumbar mobility (Table 15).

Table 15. Thoracic spine position vs lumbar flexion mobility

Thoracic kyphosis	Sex	Mobility decreased (L)	Mobility normal (L)	Mobility increased (L)
Flat	W	0 (0.00%)	4 (100%)	0 (0.00%)
	M	2 (15.38%)	11 (84.62%)	0 (0.00%)
Normal	W	2 (33.33%)	4 (66.67%)	0 (0.00%)
	M	0 (0.00%)	10 (100.00%)	0 (0.00%)
Round	W	5 (21.74)	17 (73.91%)	1 (4.35%)
	M	3 (37.50%)	5 (62.50%)	0 (0.00%)

Increased mobility in the direction of flexion in the thoracic spine was observed in just over 40% of female subjects who had a round thoracic kyphosis. In men, this relationship was observed among subjects with flat kyphosis.

Table 16. Thoracic spine position vs thoracic flexion mobility

Thoracic kyphosis	Sex	Mobility decreased (Th)	Mobility normal (Th)	Mobility increased (Th)
Flat	W	1 (25.00%)	1 (25.00%)	2 (50.00%)
	M	0 (0.00%)	0 (0.00%)	13 (100.00%)
Normal	W	2 (33.33%)	0 (0.00%)	4 (66.67%)
	M	0 (0.00%)	1 (10.00%)	9 (90.00%)
Round	W	0 (0.00%)	9 (39.13%)	14 (60.87%)
	M	0 (0.00%)	3 (37.50%)	5 (62.50%)

Discussion

The presented studies show the relationship between the position of the sacrum and the position of the lumbar and thoracic spine, and indicate the existence of a relationship between the position and mobility of the spine in the group of young women and men.

The connection between the fairly stable sacrum, pelvis and movable lumbar spine is a major challenge for the tissues. At the L5 / S1 level, many shear forces occur, which can significantly load this section.[10]. Hence, apart from a proper lifestyle, the key to reducing the load on this section is the correct arrangement of the above-mentioned structures in relation to each other. Wnuk et al. indicate that the pelvis is a fundamental element of the lumbar-pelvic complex and any dysfunctions within it may affect abnormalities observed in the body posture and cause pain.[6] Delmas observed a relationship between the position of the spine and the shape of the sacrum with its articular surface. He distinguished 3 types of connections. The first is static, in which the curves of the spine are flatter and the sacrum becomes more vertical. Another dynamic, in which the deepening of the physiological curves of the spine is accompanied by the horizontal positioning of the sacrum and indirect type. Different types of the pelvis position, and with it the sacrum, may have an impact on the size of the spine's curvature.[11] In turn, Lewit K., referring to Gutmann's research, distinguishes three types of pelvis, taking into account the position of the promontory. The first type is characterized by a long sacrum and a high promontory, the second 'middle' type has average parameters, while the third type is characterized by a low promontory and a significant pelvic inclination. He also indicates that the size of the lumbar curvature will depend on the angle of the pelvis, which in turn depends on the type of the pelvis.[12] Rakowski indicates that the position of the high pelvis (where the base of the sacrum is at an angle of 15°–30°) will affect the position of the spine by reducing curvates of lumbar lordosis, thoracic kyphosis and cervical lordosis. On the other hand, in the overload-type pelvis (where the sacrum tends with its dorsal surface to a horizontal position and its base to a vertical position), there will be a tendency to deepening of the curvature lumbar lordosis, thoracic kyphosis.[13]

The presented studies showed differences between women and men in the position of the sacrum and the lumbar spine. In almost half of the examined women, round lumbar lordosis was noted, while 2/3 of men were characterized by flat lumbar lordosis. The obtained results do not seem to be consistent with the observations of other researchers. Górniak et al., when assessing the position of the spine in the sagittal plane in the group of students (128 men and 82 women), also noted differences in the position of the lumbar spine between women and men, but among the surveyed people, almost 2/3 of the surveyed men diagnosed the correct position of the lumbar lordosis, and in every fourth men they noted flat lumbar lordosis. They observed round lordosis in 9% men. In the group of women, they noted normal and round lumbar lordosis with the same frequency.[14] On the other hand, Grabara, comparing the body posture of people practicing yoga and not practicing any activity, observed that non-training women are characterized by significantly higher values of lumbar lordosis, but did not differ from men in the position of thoracic kyphosis.[15]

Significant dependencies in the position of the lumbosacral spine were also noted in the conducted studies. Horizontal position of the sacrum coexisting with round lumbar lordosis was observed in every third woman. On the other hand, in the group of men (over 1/3 of studied), the vertical position of the sacrum appeared with flat lumbar lordosis. Król A. et al. assessed the relationship between the pelvic inclination and the position of the lumbar spine in the sagittal plane in 60 women aged between 20–26 years of age. The results of these authors indicate the existence of significant relationships between the position of the pelvis and setting of the lumbar lordosis. As lumbar lordosis increase, they noted an increase in the pelvic tilt.[16] Similar relationships were observed by Panpan H. et al. assessing global body posture in 272 young adults aged 23.2 years. They used an X-ray examination to globally assess body posture. They noted significant differences between men and women. In women, they noted higher values of lumbar lordosis and sacro-lumbar angle.[17] In turn, Demir M. et al. assessed the relationships between the position of the lumbar spine and the sacrum in women and men aged 18–27. They did not find significant differences in the size of lumbar lordosis between women and men. However, they observed significant positive relationships between the lumbar lordosis angle, the pelvic inclination angle and the values of the sacral angle, and a negative relationship with the lumbosacral angle.[18] Similar observations were made by Yukawa et al. Researchers assessed the position of the spine and hip joints in 626 subjects aged 20–79. The studied group was divided into 6 smaller groups, taking into account the age of the respondents. They noted no significant differences in the position of the thoracic and lumbar spine and the sacra slope in the group of young adults aged 20–29 years. The observed differences in the results of the cited studies may result from the use of various research tools.

The available literature draws attention to the relationship between the position of the pelvis, sacrum, lumbar spine and hip joints. The balance between the above-mentioned structures is crucial. Many of researchers is unanimous about the relationship between the position of the sacrum and the lumbar spine. Studies conducted by Youp Cho et al. in a group of 30 men without pain in the lumbar region showed a strong correlation between a reduction in lumbar lordosis and a decrease in sacral slope, as well as between a reduction in lumbar lordosis and an increase in pelvic tilt. In a sitting position, the pelvis tilts back and a reduction in lumbar lordosis is observed, as well as a sacral slope, i.e. the sacrum bone is vertically positioned, pelvic tilt increases and pelvic retroversion is observed. When standing, the pelvic tilt is dictated by pelvic incidence and the lumbar spine conforms to the sacral slope as the lower limbs remain straight.[20-24] In the case of a vertical pelvis, pelvic incidence and sacral slope values are low, the angle of the pelvis is smaller. The pelvis is tilted back, which in turn leads to stiffening of the hip joints, which begin to compensate for the mobility of the pelvis. The opposite is true for a more horizontal pelvis, then the pelvic incidence and sacral slope are high, the greater the inclination of the pelvis. However, the hip extension is smaller, which limits the mobility of the pelvis.[25] Similar observations were made by Legaye et al. While assessing the X-ray images, the researchers observed significant relationships between the structures that make up the sacro-pelvic complex.[26] Changes in the angle values of the pelvic incidence and sacra slope parameters may be the cause of pain complaints reported by patients. On the other hand, Boulay et al. (2006), by assessing radiographs of 149 healthy people aged 19–50, confirmed the relationship between pelvic incidence and the position of the spine and pelvis in the sagittal plane. The position of the lumbar spine is strongly related to the position of the pelvis.[27]

The lumbar spine is the second segment, right after the cervical spine, where, due to its structure, the greatest possible mobility in the sagittal plane is found.[28] Maintaining mobility and the correct lumbosacral rhythm is an important element that can prevent overloads within the lumbosacral section. In the presented studies, normal mobility of the lumbar spine was noted in women and in over 80% of men. Additionally, increased mobility in the direction of flexion in the thoracic segment was observed both in the group of women and men. Both in the group of women and men, increased mobility in the thoracic segment was most often associated with normal mobility in the lumbar region. Sahrmann et al. indicate that the body at the joint level will always follow the path of least resistance to motion, usually in a specific direction such as flexion, extension or rotation. Researchers emphasize the role of the so-called relative flexibility both within and between joints; relative muscle and connective tissue stiffness; and motor performance. When movement is performed in multiple joints, the body will tend to increase the amount of movement in the joint with less resistance to movement or less stiffness than in a joint with more resistance to movement or greater stiffness.[5] In the case of the lumbar spine, when performing a forward bend, the ideal pattern is the even bend of the lumbar and thoracic spine with a simultaneous bend of the hips approx. 70°. In the case of reduced hip mobility (reduced flexibility of the hamstring muscles), there may be a compensatory increase in flexion in the lumbar spine. Repeated patterns can cause musculoskeletal pain.

Studies conducted by Esola et al. have shown that in people with lower back pain a greater bend in the lumbar spine during the initial phase of the bend and greater stiffness of the hamstring muscles occur compared to people without complaints.[4,29] The available literature emphasizes that imbalance in the strength of the trunk muscles may significantly affect the position of lumbar lordosis and may be a risk factor for the emergence of low back pain. People with round lumbar lordosis and decreased abdominal muscle strength are at increased risk of chronic lower back pain.[30] Dysfunctions occurring within the lumbar-pelvic complex weaken the strength of the gluteus muscles, multifidus muscles and transverse abdominal muscles. Olson, in turn, observed that dysfunction of the sacroiliac joints is more common in women. According to the author, the cause may be sexual dimorphism. Women have flatter and smoother articular surfaces, in addition, the axis of the hip joints is more distant than in men from the line running through the center of gravity. The hormonal factor as well as the burdens and injuries associated with childbirth are also emphasized.[31]

The obtained results also showed significant relationships between the position of the lumbar spine and the position of the thoracic spine. In the examined women, the most common was round lumbar lordosis along with round thoracic kyphosis, while in men, flat lumbar lordosis was most often associated with a flat thoracic kyphosis. It seems that the results obtained in the group of women are consistent with the observations of other researchers. Górniak et al., while assessing the position of the spine in the sagittal plane, observed the presence of positive correlations between the position of lordosis and kyphosis both in the group of women and men. Women were characterized by higher values of kyphosis and lordosis as well as pelvic inclination.[14] Research shows that thoracic kyphosis worsens with age, and lumbar lordosis decreases32. Research by Briggs et al. indicate that higher kyphosis values may contribute to the earlier occurrence of functional and degenerative changes.[33]

Conclusions

1. The position of the sacrum significantly affects the positioning of the lumbar region in both women and men. In women, the most frequently observed was the horizontal position of the sacrum coexisting with round lordosis, while in men the vertical position of the sacrum coexisting with flat lumbar lordosis was observed.
2. In the group of women, more often observed were round thoracic kyphosis, a smaller range of motion in the direction of flexion and extension in the thoracic section, and greater mobility in the direction of flexion and extension in the lumbar region than in the group of men. In the group of men the decrease in lordosis increased the movement to flexion in the thoracic spine.
3. When planning a program of physiotherapy exercises for a person diagnosed with irregularities in the position of the lumbar-pelvic complex, an individual exercise program should be selected. The examination should take into account not only the assessment of the position of the lumbosacral spine, but also the analysis of the mobility of the spine, taking into account gender differences.

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