J Surg Med. 2020;4(6):486-490.
DOI: 10.28982/josam.735849

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN=2602-2079

Evaluation of scoliosis in patients with lumbosacral transitional vertebra

Lumbosakral tranzisyonel vertebralı hastalarda skolyozun değerlendirilmesi

Tuba Selçuk Can [1,2]

[1] Istanbul Gelisim University, Institute of Health Sciences, Istanbul, Turkey
[2] University of Health Sciences, Haseki Education and Research Hospital, Fatih, Istanbul, Turkey

ORCID ID of the author(s)
HK: 0000-0001-9633-3173
UY: 0000-0002-0187-5381

Abstract

Aim: Lumbosacral transitional vertebra and scoliosis both have the potential to alter spinal balance, along with psoas muscles, which are important in the maintenance of spinal alignment. In this study we aimed to evaluate the relationship between lumbosacral transitional vertebrae and their potential influence on lumbar alignment.

Methods: In this cross-sectional study, lumbar Magnetic Resonance Imaging (MRI) studies that are referred to our Radiology Department between January 2017 and July 2017 were evaluated. 125 patients with lumbosacral transitional vertebra and 125 patients without any history of previous spinal surgery, trauma, inflammatory or infectious diseases were included. Type of transitional vertebra (unilateral/bilateral), presence of scoliosis and psoas muscle diameter-area measurements were evaluated.

Results: Among the transitional vertebra group, 75 patients had unilateral and 50 had bilateral sacralization. Among sacralization patients, 52.8% also had scoliosis. The presence of scoliosis was significantly lower in patients with bilateral sacralization compared to those with unilateral sacralization (P=0.001). The psoas muscle cross-sectional area and diameters were also further evaluated for the presence of asymmetry in the scoliosis group. Measurements were made twice by one radiologist and the mean value was used for statistical analysis. Results showed that area and transverse diameter asymmetries were statistically significant in patients with scoliosis (P=0.001 and P=0.003, respectively).

Conclusions: Lumbosacral transitional vertebra deteriorates spinal alignments and particularly when unilateral, may cause scoliosis and psoas muscle asymmetry. The pathophysiology of psoas muscle asymmetry, however, is controversial and should be further evaluated.

Keywords: Lumbosacral transitional vertebra, Magnetic resonance imaging, Scoliosis, Psoas muscles

Öz

Amaç: Lumbosakral tranzsiyonel vertebra ve skolyozun her ikisinin de spinal dengeyi değiştirebilecek potansiyel etkileri bulunmaktadır. Psoas kasları ise spinal dengenin sağlanmasında önemli göreve sahiptir. Bu çalışmada lumbosakral tranzsiyonel vertebra ile spinal dizilim arasındaki ilişkiyi değerlendirmeyi amaçladık.

Yöntemler: Bu kesitsel çalışmada hastanemizin Radyoloji Bölümü'nde Ocak 2017-Temmuz 2017 tarihleri arasında çekilen Lomber Manyetik Rezonans Görüntüleme tetkikleri retrospektif olarak değerlendirildi. Tranzisyonel vertebralı 125 hasta ile spinal cerrahi, travma, inflamatuar ya da enfeksiyöz bir hastalık öyküsü bulunmayan 125 hasta control grubu olarak çalışmaya dahil edildi. Tranzisyonel vertebranın yönü (unilateral, bilateral), skolyoz varlığı ve psoas kası çap ile alanları değerlendirildi.

Bulgular: Tranzisyonel vertebralı hastaların 75'i unilateral 50'si ise bilateral sakralizasyona sahipti. Sakralizasyonu olan hastaların %52,8'inde aynı zamanda skolyoz mevcuttu. Bilateral sakralizasyonu olan hastalarda unilateral sakralizasyonu olan hastalara kıyasla skolyoz anlamlı derecede daha az saptandı (P=0,001). Skolyoz grubunda psoas kası asimetri durumunu saptamak için psoas kas çapları ve kesitsel alanları değerlendirildi. Ölçümler aynı radyolog tarafından iki kere yapılarak ortalama değer istatistiksel değerlendirmede kullanıldı. Skolyozlu hastalarda psoas kaslarının alanlarında ve transvers çaplarında anlamlı oranda asimetri olduğu görüldü (sırasıyla P=0,001 ve P=0,003).

Sonuç: Lumbosakral tranzisyonel vertebra spinal dizilimi bozmakta ve özellikler tek taraflı olduğunda skolyoza ve psoas kası asimetrisine neden olmaktadır. Psoas kası asimetrisinin altındaki patofizyoloji kesin olmayıp ileri çalışmalarla desteklenmelidir.

Anahtar kelimeler: Lumbosakral tranzisyonel vertebra, Manyetik rezonans görüntüleme, Skolyoz, Psoas kası

Corresponding author/Sorumlu yazar:
Tuba Selçuk Can
Address/Adres: Haseki Eğitim ve Araştırma Hastanesi, Sağlık Bilimleri Üniversitesi, Adnan Adıvar Caddesi, No: 9, 34130, Fatih, İstanbul, Türkiye
e-Mail: drtubas@gmail.com

Ethics Committee Approval: Ethical approval of was obtained from Gelisim University Ethical Committee (2/14/2019, 2019-3-6). All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.
Etik Kurul Onayı: Etik onayı Gelişim Üniversitesi Etik Kurulundan (14.02.2019, 2019-3-6) alınmıştır. İnsan katılımcıların katıldığı çalışmalardaki tüm prosedürler, 1964 Helsinki Deklarasyonu ve daha sonra yapılan değişiklikler uyarınca gerçekleştirilmiştir.

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Published: 6/30/2020
Yayın Tarihi: 30.06.2020

How to cite/Atıf için: Can TS. Evaluation of scoliosis in patients with lumbosacral transitional vertebra. J Surg Med. 2020;4(6):486-490.

Introduction

According to Becker et al. [1], lumbar pain is recognized as a common cause of hospital visits and is mostly not related to any one single mechanism. Notably, Lumbosacral Transitional Vertebrae (LSTV) are anomalies that involve the sacralization of the lower lumbar vertebrae and lumbarization of the upper sacral vertebrae, with a reported frequency of 4-21% in the population [2,3]. Castellvi et al. [4] defined four LSTV types, varying from dysplastic transverse process to complete fusion with sacral ala, both of which can be seen unilaterally or bilaterally. As reported by Almeida et al. [5] and Paajanen et al. [6], Bartolotti Syndrome was established as the cause of lumbar pain in 1917, and its relationship with back pain and disc degeneration in adjacent segments was studied by various researchers.

Scoliosis is a spinal deformity which may be related to congenital abnormalities or various neuromuscular diseases. It may also develop secondarily to degenerative changes [7]. Additionally, in degenerative scoliosis, asymmetry in facet joint orientation and degeneration as well as an asymmetric compression fracture are thought to be the cause of the scoliosis [8]. The lumbar muscles are structures that support the stability of the spine along with discs and facet joints [9]. Muscle strength is directly proportional to the cross-sectional area of the muscle and the fibers contained in the muscle, and in many studies, muscle planimetry was used to assess muscle strength [2].

The present study aimed to determine the relationship between LSTV and scoliosis and evaluate psoas muscle asymmetry at the scoliosis level.

Materials and methods

Population

In this cross-sectional study, Lumbar MRI examinations performed in our institution for lower back pain between January and July 2017 were reviewed. Approval of Gelisim University Ethics Committee (14.02.2019, 2019-3-6) was obtained. Patients with a history of surgery, trauma, and malignancy, and patients who underwent an MRI examination due to inflammatory or infectious diseases of the spinal cord and vertebrae were excluded in order to minimize the potential additional causes that may disturb spinal alignment. Patients who had LSTV with lumbarization of the first sacral vertebra were not included in our study. The study included two groups: A population of 125 patients with an LSTV anomaly with unilateral or bilateral sacralization of the last lumbar vertebra, and a control group of 125 whose MRI examinations reported "lumbar MRI examination within normal limits". Both groups had an equal gender distribution of (52.8% female, 47.2% male). The age of participants in the LSTV with sacralization group ranged from 15 to 78 years, with a mean of 44.62 (14.84) years. The age of the control group ranged from 13 to 70 years, with a mean value of 39.09 (11.85) years.

Image analysis

All lumbar MRI images were performed according to the standard lumbar MRI protocol (Axial T2-weighted fast spin echo; TR: 3800, TE: 100, Sagittal T2-weighted fast spin echo; TR: 2500, TE: 100, Sagittal T1-weighted spin echo TR:500, TE:10) with a 1.5 T Philips Achieva MRI device (Philips Healthcare, Best, The Netherlands). The images were evaluated at the workstation (INFINITT PACS, Infinitt Healthcare, South Korea) by a radiologist with >5 years of experience in spinal imaging. LSTV anatomy and type were determined based on full spine coronal plane localizer images and verified with the roentgenogram of the patients as well as with axial MR images by the presence of articulation, pseudo-articulation, or fusion of the fifth lumbar vertebra with sacrum (sacralization) (Figure 1). Coronal localizer images were evaluated for the presence of scoliosis and lumbar vertebral roentgenograms of patients were further checked for their Cobb angle measurement (Figure 2). Following the measurement, we determined the curvature type. Right-sided curvature of the scoliosis is called dextroscoliosis and its left-sided counterpart is levoscoliosis. Axial T2A MRI sections were used for psoas muscle area and diameter measurements.

Figure 1: Bilateral sacralization and pseudoarticulation of L5 vertebra with sacrum is seen on axial T2-weighted MR image.

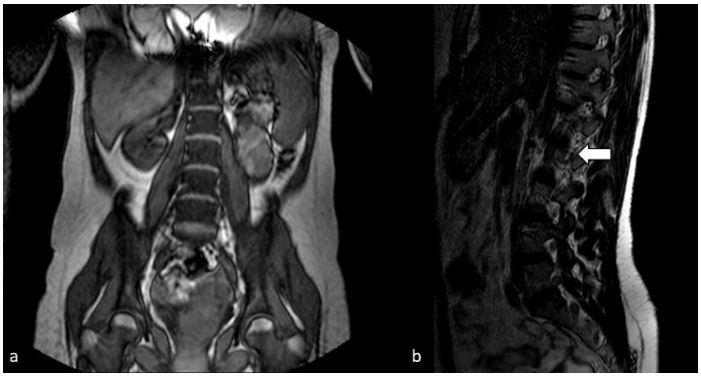

Figure 2: Coronal lumbar survey image (a) showing the scoliosis and T2-weighted sagittal image (b) of the same patient. Not all the vertebrae are on the same line because of scoliosis, also showing the suspected apex of the curvature (arrow).

Measurements were made on the Infinitt PACS system at the level of cross-sections between the lower limit of the L4 vertebrae and the upper limit of the L5 vertebra. Area measurements were calculated in mm² by drawing the psoas muscle limits manually using polygonal ROI. Anteroposterior (AP) diameter measurement was made such that it would pass through the midpoint of the sagittal plane of the psoas muscle, and the transverse diameter measurement was made such that it would pass through the middle section of the psoas muscle in the coronal plane (Figure 3). Measurements were made by the same radiologist twice, and the mean value of two measurements was used in statistical data.

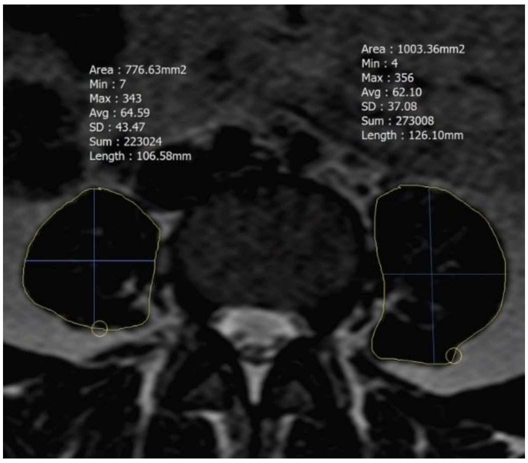

Figure 3: Axial T2-weighted image, psoas muscle area measurements are done with polygonal ROI (yellow) and diameter measurements (anterior-posterior and transverse) are seen (blue).

Statistical analysis

Statistical analysis of the data was made by using SPSS (Statistical Package for the Social Sciences) version 15.0. Data of the continuous variables were indicated as the mean (standard deviation), median and interval, and categorical variables frequency and percentage. The Pearson correlation test was used for correlations, Fisher's exact test and Chi-Square test for the categorical variables in the analyses in which the intergroup comparisons were made, and Student's t-test and Mann Whitney U test for the continuous variables. The results were evaluated with a 95% confidence interval, and the significance level was accepted as $P<0.05$.

Results

In patients with sacralization, unilateral sacralization was detected in 75 (right: 32, left: 43) and bilateral sacralization in 50. Simultaneous scoliosis was detected in 52.8% (n=66) of patients with sacralization. The mean (SD) Cobb angle was 14.3 (1.1)° in scoliosis patients. The apex of scoliosis was mostly at the L3 level (31.2%), followed by L2 (6.4%), L1 and L4 (4.8%), T12 (3.2%) and T11 (2.4%) respectively. Among scoliosis patients, 40 patients had levoscoliosis and 26 had dextroscoliosis.

When the relationship between unilateral or bilateral sacralization and the presence and direction of scoliosis were evaluated, the presence of scoliosis was significantly lower in the patient group with bilateral sacralization than in the unilateral sacralization group ($P<0.001$) (Table 1).

In the group of patients with unilateral sacralization, the frequency of dextroscoliosis was significantly higher in patients with right-sided sacralization ($P=0.003$) (Table 2). In patients with left-sided sacralization, the percentage of dextroscoliosis and levoscoliosis were the same ($P=0.06$) (Table 3).

The difference in the right-left psoas area and psoas transverse diameter were significantly greater in the scoliosis group when compared to the group without scoliosis ($P=0.001$ and $P=0.003$, respectively). The difference in right-left psoas AP diameter was higher but not statistically significant ($P=0.179$) (Table 4).

The right-left psoas area, psoas AP diameter, and psoas transverse diameter differences were significantly higher in the concave side of the curvature in the scoliosis group when compared with the control group ($P=0.001$) (Table 5).

Table 1: The presence of scoliosis regarding unilateral sacralization and bilateral sacralization

	Unilateral sacralization		Bilateral sacralization		*P*-value
	n	%	n	%	
Scoliosis					
(-)	24	32.0	35	70.0	0.001
(+)	51	68.0	15	30.0	

Table 2: Scoliosis status only by the presence of right sacralization

	Right Sacralization (+)		*P*-value
	n	%	
Dextroscoliosis			
(-)	15	46.9	0.003
(+)	17	53.1	
Levoscoliosis			
(-)	24	75.0	0.497
(+)	8	25.0	

Table 3: Scoliosis status only by the presence of left sacralization

	Left Sacralization (+)		
	n	%	*P*-value
Right scoliosis			
(-)	30	69.8	0.759
(+)	13	30.2	
Left scoliosis			
(-)	30	69.8	0.060
(+)	13	30.2	

Table 4: Comparison of the presence of scoliosis and psoas measurements in patients with sacralization

Right-left	Scoliosis (+) Patient Group			Scoliosis (-) Patient Group			*P*-
difference	Mean	SD	Median	Mean	SD	Median	value
Psoas area	1.1894	1.0826	0.950	0.7017	0.7406	0.400	0.001
Psoas AP diameter	0.3939	0.3167	0.350	0.2983	0.2169	0.200	0.179
Psoas TRV diameter	0.4258	0.3045	0.300	0.2729	0.2219	0.200	0.003

SD: Standard deviation, AP: Anteroposterior, TRV: Transverse

Table 5. Comparison of the differences between right and left psoas areas and diameters of scoliosis patients and control group

Right-left	Scoliosis (+) Patient Group			Control Group			*P*-
difference	Mean	SD	Median	Mean	SD	Median	value
Psoas area	1.1894	1.0826	0.950	0.4720	0.3505	0.400	0.001
Psoas AP diameter	0.3939	0.3167	0.350	0.1864	0.1973	0.200	0.001
Psoas TRV diameter	0.4258	0.3045	0.300	0.1928	0.1587	0.100	0.001

SD: Standard deviation, AP: Anteroposterior, TRV: Transverse

Right-left psoas AP diameter and psoas TRV diameters were statistically significantly higher in patients without scoliosis than the control group ($P<0.001$ and $P=0.016$, respectively). The mean difference of the right-left psoas area was higher, yet not statistically significant ($P=0.203$) (Table 6).

The right-left psoas muscle area and diameter differences of the patient group with scoliosis, the patient group without scoliosis, and the control group are shown in Figure 4.

Table 6: Comparison of right-left psoas area and diameters of patients without scoliosis and control group

Right-left	Scoliosis (-) Patient Group			Control Group			*P*-
difference	Mean	SD	Median	Mean	SD	Median	value
Psoas area	0.7017	0.7406	0.400	0.4720	0.3505	0.400	0.203
Psoas AP diameter	0.2983	0.2169	0.200	0.1864	0.1973	0.200	<0.001
Psoas TRV diameter	0.2729	0.2219	0.200	0.1928	0.1587	0.100	0.016

SD: Standard deviation, AP: Anteroposterior, TRV: Transverse

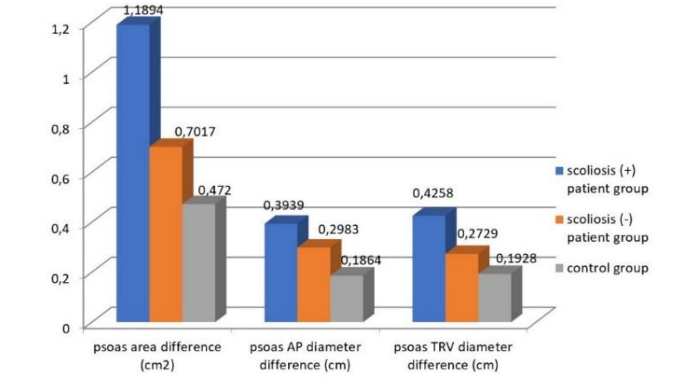

Figure 4: Right-left psoas muscle area and diameter differences of the patient group with scoliosis, a patient group without scoliosis, and the control group (cm: centimeter, AP: Anteroposterior, TRV: Transverse)

Discussion

Intervertebral discs, alignment of vertebrae, facet joints, and paraspinal muscle groups play an essential role in the stability of the spine. For efficient and normal functioning facet joints, disc and alignment are significant. Based on this, we created the following hypothesis: In the presence of pseudo-articulation or fusion formation of sacrum with the transverse process of L5 vertebrae (L5 sacralization), the regular anatomy of the lumbosacral junction would deteriorate so that the mechanical balance in this area would also be disrupted. This, in turn, would result in scoliosis – especially in patients with unilateral LSTV. According to Nardo, et al. [10] and deBruin, et al. [11], the relationship between LSTV and both the lumbar pain and degenerative changes in adjacent segments were depicted. However, their relationship with scoliosis is not clear. Technically, the results of our study confirmed our hypothesis, and scoliosis was lower in patients with bilateral sacralization than in the unilateral group. In patients with unilateral sacralization, the scoliosis curvature opening was seen towards the side of the sacralization. While this relationship was statistically significant on the right side, and there was a similar but insignificant relationship on the left side. Scoliosis curvature concavity towards the sacralization side cannot be explained by the spasm that occurred in the psoas muscle on the side where the mechanic is deteriorated, because in this case, the top of the scoliosis curve would be on the side where the sacralization was, and the concavity would face the opposite side [12]. The lack of statistical significance may be related to the fact that the number of patients with left-sided scoliosis was less than the right-sided group.

When psoas asymmetry was evaluated in the presence of scoliosis accompanying sacralization, we found that there was significant psoas asymmetry between the right and left side both in patients with scoliosis, compared to the control group, and in the patients with sacralization but without scoliosis. In this asymmetry, we found that the psoas area and diameters were greater on the concave side where the opening of the scoliosis was observed. However, here it is controversial whether scoliosis or psoas asymmetry develops first. According to Panjabi [12], the psoas muscle and paravertebral muscles are clearly the dynamic stabilizers of the vertebrae. Accordingly, Panjabi suggested that the cross-sectional areas of the psoas and multifidus muscles would be more on the convex side in people with scoliosis and further maintained that this was a compensation mechanism to establish the coronal balance.

Similarly, Kim, et al. [13], evaluated the cross-sectional areas of paravertebral and psoas muscles in degenerative scoliosis, finding that the areas on the convex side were more significant at the top level of scoliosis. However, the present study showed that the psoas areas were larger on the concave side, a result which corresponds to the hypothesis that the muscles on the concave side should be shorter and thicker, as the muscles on the convex side – due to the asymmetry in the coronal plane of the vertebra in scoliosis – should be more taut and thin. In this hypothesis, psoas asymmetry is a result rather than a cause. In the present study, psoas asymmetry was statistically significant in sacralization patients with and without scoliosis, suggesting the presence of LSTV – an essential parameter in our study – was effective on the development of scoliosis. The fact that the frequency of scoliosis was higher in patients with unilateral sacralization than in patients with bilateral sacralization also supports this hypothesis. In this context, scoliosis may develop primarily in patients with unilateral sacralization, and psoas asymmetry may then subsequently occur. However, the causal mechanism in the development of scoliosis is unclear.

Dangaria et al. [14] investigated the relationship between disc herniation and psoas muscle area and found a reduction in muscle area on the affected side. Danneels et al. [8], however, revealed that there was no difference in the psoas muscles of people with lumbar pain. In another study, Wan et al. [15] investigated the changes in paraspinal muscles in people with lumbar pain and found a reduction in paraspinal muscle areas due to reflex inhibition on the side with pain. LSTV and scoliosis were evaluated as factors of to affect psoas muscle in our study. No evaluation was made for the presence of pain in patients. Therefore, the relationship between reflex inhibition and pain and atrophy secondary to the process in our study is unknown. However, when it is considered that the pain is on the side of sacralization – the primary pathology – the absence of atrophy on the ipsilateral psoas muscle in our study suggests that this mechanism does not affect the current pathology.

When we evaluated our study results in comparison with other studies in which the psoas muscle on the convex side of scoliosis was expected to have a smaller diameter, in our study, conversely, the psoas muscle dimensions were more prominent. This was the result of a cause-effect relationship rather than a compensation mechanism. In light of these findings it may be that scoliosis develops primarily on the side of sacralization in patients with LSTV and that the muscles consequently become shorter and thicker on the openness-side, and longer and thinner on the other side.

Limitations

Limitations of the present study include the fact that paraspinal muscles which provide spinal stability were not evaluated, and only the psoas muscle was assessed. The control group consisted of patients with lumbar complaints even though they had standard lumbar MRI images. We only included patients with sacralization that was confirmed on axial and survey images and we excluded patients with lumbarization among transitional vertebra patients and that may be a potential source of bias.

Conclusions

This study shows that the mechanical balance which provides spinal stability in LSTV patients is deteriorated, especially in patients with unilateral LSTV, and that this may lead to the development of scoliosis and psoas muscle asymmetry in these patients. Psoas muscle cross-sectional areas tend to be more prominent and thicker on the concave side in patients with sacralization accompanied by scoliosis, and the causative mechanism is unclear. The presence of sacralization and its unilaterality are risk factors in the development of scoliosis and related pathologies. We believe that an awareness of this information would be helpful in planning patient-specific treatment to prevent the development of scoliosis.

References

1. Becker A, Held H, Redaelli M, Strauch K, Chenot JF, Leonhardt C, et al. Low back pain in primary care: costs of care and prediction of future health care utilization. Spine. 2010;35(18):1714–20.
2. Richard J. H., Asif S. Numbering of Lumbosacral Transitional Vertebrae on MRI: Role of the Iliolumbar Ligaments. AJR. 2006;187:59-66.
3. Gundogdu E. Rare and overlooked two diagnoses in low back pain: Osteitis condensans ilii and lumbosacral transitional vertebrae. J Surg Med. 2018;2(3):320-3.
4. Castellvi AE, Goldstein LA, Chan DPK. Lumbosacral transitional vertebrae and their relationship with lumbar extradural defects. Spine. 1984;9:493–5.
5. Almeida DB, Mattei TA, Sória MG, Prandini MN, Leal AG, Milano JB, et al. Transitional lumbosacral vertebrae and low back pain: diagnostic pitfalls and management of Bertolotti's syndrome. Arq Neuropsiquiatr. 2009;67:268-72.
6. Paajanen H, Erkintalo M, Kuusela T, Dahlstrom S, Kormano M. Magnetic resonance study of disc de generation in young low-back pain patients. Spine (Phila Pa 1976). 1989;14:982-5.
7. Ashour R, Jankovic J. Joint and skeletal deformities in Parkinson's disease, multiple system atrophy, and progressive supranuclear palsy. Mov Disord. 2006 Nov;21(11):1856-83.
8. Aebi M. The adult scoliosis. Eur Spine J. 2005;14(10):925–48.
9. Danneels LA, Vanderstraeten GG, Cambier DC, Witvrouw EE, De Cuyper HJ. CT imaging of trunk muscles in chronic low back pain patients and healthy control subjects. Eur Spine J. 2000;9:266-72.
10. Nardo L, Alizai H, Virayavanich W, Liu F, Hernandez A, Lynch JA, et al. Lumbosacral Transitional Vertebrae: Association with Low Back Pain. Radiology. 2012;265:497-503.
11. de Bruin F, Ter Horst S, Bloem JL, van den Berg R, de Hooge M, van Gaalen F, et al. Prevalence and clinical significance of lumbosacral transitional vertebra (LSTV) in a young back pain population with suspected axial spondyloarthritis: results of the SPondyloArthritis Caught Early (SPACE) cohort. Skeletal Radiol. 2017;46:633–9. doi: 10.1007/s00256-017-2581-1
12. Panjabi MM. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. J Spinal Disord. 1992;5:390-396; discussion 397.
13. Hyoungmin K, Choon-Ki L, Jin SY, Jae HL, Jae HC, Shin SI, Lee HJ, et al. Asymmetry of the cross-sectional area of paravertebral and psoas muscle in patients with degenerative scoliosis. Eur Spine J. 2013;22:1332–8. DOI: 10.1007/s00586-013-2740-6.
14. Dangaria TR, Naesh O. Changes in cross-sectional area of psoas major muscle in unilateral sciatica caused by disc herniation. Spine (Phila Pa 1976). 1998;23:928-31.
15. Wan Q, Lin C, Li X, ZengW, Ma C. MRI assessment of paraspinal muscles in patients with acute and chronic unilateral low back pain. Br J Radiol. 2015;88:20140546.

This paper has been checked for language accuracy by JOSAM editors.
The National Library of Medicine (NLM) citation style guide has been used in this paper.