Black Sea Journal of Health Science
doi: 10.19127/bshealthscience.1553323

Open Access Journal
e-ISSN: 2619 – 9041

Research Article
Volume 7 - Issue 6: 248-252 / November 2024

MORPHOLOGICAL CHANGES IN THE LUMBAR AND ABDOMINAL MUSCLES IN INDIVIDUALS WITH SACRALIZATION

Fatih ÇANKAL[1], İlyas UÇAR[2]*, Caner KARARTI[3], Selim ÇINAROĞLU[4]

[1]*Ankara Medipol University, Faculty of Medicine, Department of Radiology, 06000, Ankara, Türkiye*
[2]*Erciyes University, Faculty of Medicine, Department of Anatomy, 38100, Kayseri, Türkiye*
[3]*Kırşehir Ahi Evran University, School of Physical Therapy and Rehabilitation, Department of Physiotherapy and Rehabilitation, 40100, Kırşehir, Türkiye*
[4]*Niğde Ömer Halis Demir University, Faculty of Medicine, Department of Anatomy, 51000, Niğde, Türkiye*

Abstract: Although sacralization is one of the most common congenital anomalies of the spine, its effect on surrounding muscles is still not well known. This study was conducted to determine the size of the lumbar and abdominal muscles of the individuals with sacralization and to compare with the control group. Eighty-five participants with sacralization phenomena and fifty-six asymptomatic participants were included in this study. Sacralization was classified according to the Castellvi classification. The cross-sectional area of the multifidus lumborum, erector spinae and rectus abdominis muscles, and the section thicknesses of external abdominal oblique, internal abdominal oblique and transversus abdominis muscles were measured bilaterally on axial computed tomography images at the L1-2 and L4-5 levels. ANCOVA revealed that there is no any significant group*side interaction effect regarding muscles sizes in terms of two groups in L1-L2 and L4-L5. In addition, ANCOVA revealed a both side effect [($P=0.020$; $\eta 2p=0.038$)] and group*side interaction effect [($P=0.010$; $\eta 2p=0.049$)] regarding length of the L5 transverse process ($P>0.05$). Regardless of low back pain, muscle sizes are not associated with the sacralization phenomenon.

Keywords: Sacralization, Computed tomography, Paraspinal muscles, Abdominal muscles

***Corresponding author:** Erciyes University, Faculty of Medicine, Department of Anatomy, 38100, Kayseri, Türkiye
E mail: ilyas.ucar@erciyes.edu.tr (İ. UÇAR)
Fatih ÇANKAL https://orcid.org/0000-0003-1066-353X
İlyas UÇAR https://orcid.org/0000-0003-3646-5320
Caner KARARTI https://orcid.org/0000-0002-4655-0986
Selim ÇINAROĞLU https://orcid.org/0000-0002-4495-6106

Received: September 20, 2024
Accepted: October 25, 2024
Published: November 15, 2024

Cite as: Çankal F, Uçar İ, Karartı C, Çınaroğlu S. 2024. Morphological changes in the lumbar and abdominal muscles in individuals with sacralization. BSJ Health Sci, 7(6): 248-252.

1. Introduction

Lumbosacral transitional vertebra (LSTV) is a congenital anomaly seen in approximately one out of every four people in the population, and it includes a spectrum from complete/incomplete L5 sacralization to complete/incomplete S1 lumbarization according to morphological changes (Dar and Peled, 2014). Sacralization, which is one of these anomalies, is the fusion of the fifth lumbar vertebra with the first sacral vertebra in different ways and gaining the characteristic of the sacrum (Carrino et al., 2011). Several authors have reported the incidence of sacralization, which is mostly found incidentally as 4.6-35.9% in the general population (Castellvi, 1984; Hughes and Saifuddin, 2006; Hinterdorfer et al., 2010). In clinical studies, it has been shown that with sacralization, mobility in the lumbar region decreases and it is asymmetrical, and may also cause early degenerative changes (Paik et al., 2013). When mobility is reduced or asymmetrical, changes in muscle structure and size are inevitable. However, studies examining the morphology of both lumbar and abdominal muscles in LSTV anomaly are limited (Becker et al., 2021). However, previous studies have shown that morphological changes can occur in the spine and abdominal muscles in different disorders involving the lumbar region, and that examining the anatomical structures of the musculoskeletal system can provide information about the limits of stability (Uçar et al., 2021). In this context, it was aimed to determine the dimensions of the multifidus, erector spinae and abdominal muscles of the individuals with sacralization in the lower and upper lumbar regions and to compare them with the control group in our study. In addition, by revealing the muscle dimensions of individuals with sacralization, we aim to guide the determination of the treatment protocol for the waist problems encountered in these individuals.

2. Materials and Methods

2.1. Patient Population

In our study, the images of patients aged 18-65 years, who applied to our imaging center with preliminary diagnoses such as urinary system stones, intestinal and visceral organ pathologies, and whose imaging method were computed tomography (CT), between January 2020 and December 2021, scanned retrospectively from the

PACS imaging system. Images of patients with a history of surgery involving the spine, ribs or pelvis, fractures of these bones, a history of spinal cord injury, tumor or infection, and pathology such as arthrosis, spondylolisthesis, and scoliosis were excluded from the study. The images were examined by a specialist radiologist for sacralization, and they were divided into sacralization and control groups, and the body mass index (BMI weight/height^2) was calculated by recording the age, gender, and weight and height information of the patients.

2.2. Computed Tomography Images and Classification

Images of Abdominopelvic examinations taken in the supine position with a multi-slice computed tomography device (MSCT) (General Electric IQ™ 32-Detector Spiral MSCT) without contrast were used. The acquisition parameters are 200-320 mAS, 120 kV, average 350 mm FOV and 1.25 mm section thickness. Images were evaluated both axial and coronal on the workstation, both in the bone window and in the soft tissue window.

LSTV's were recorded as unilateral or bilateral as well as incomplete or complete classification according to Castellvi classification (Castellvi 1984). Type 1 shows unilateral (1a) or bilateral (1b) elongated dysplastic transverse processes, while type 2 includes incomplete unilateral (2a) or bilateral (2b) pseudo-articulation with diarthrodial joint. Type 3 exhibits unilateral (3a) or bilateral (3b) bone fusion of the transverse process. Type 4 includes a unilateral type II with a type III on the contralateral side.

2.3. Evaluation of the Multifidus Lumborum, Erector Spinae and Abdominal Muscles

As the first step in image processing, CT images were opened in RadiAnt, a free DICOM imaging program. CT imagings were recorded in JPEG (Joint Photographic Experts Group) format to calculate the cross-sectional area of the multifidus lumborum muscle (MM), erector spinae muscle (ES) and rectus abdominis muscle (RA) and the section thicknesses of abdominal muscles (external abdominal oblique muscle 'EO', internal abdominal oblique muscle 'IO' and transversus abdominis muscle 'TA'). Then, all these images were displayed simultaneously in the "ImageJ" program, which can be downloaded from https://imagej.nih.gov/ij/download.html. An image series was created by selecting "stack→image to stack" icon under the "image" tab of the ImageJ program. Using the options in the "measurement and tools" tab on the RadiAnt program, the length of any specific spot on the image was measured. In the ImageJ program, the same spot was marked in the same section using the "straight" button. The images were calibrated using "Set Calibrate" option under the "analyze" tab of the ImageJ program (Uçar et al., 2022). In the next step, the boundaries of the MM, ES and RA muscles were determined manually by using the "Free Hand" button of the ImageJ program bilaterally in the axial images at the L1-L2 and L4-L5 levels, and the cross-sectional area was recorded in square centimeters (Figure 1). The section thicknesses of the EO, IO and TA were recorded in millimeters on the transverse line connecting the farthest points of the abdominal wall on the right and left (Figure 1). All these processes were performed on the CT image of each individual separately on the right and left.

2.4. Statistical Analysis

The data were evaluated using the Statistical Package for the Social Sciences 22.0 program for Windows. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Simirnov/Shapiro-Wilk's test) to check normality. We used descriptive statistics and reported counts and proportions for categorical data and measures of distribution for continuous data. An independent t test or χ^2 test was performed to compare the baseline characteristics. To evaluate the cross-sectional areas of muscles by using CT, a 2*2 [group (participants with- and without sacralization) * side (right or left)] repeated measures ANCOVA was performed with group as a between-groups factor and side as a within-subjects factor, and with demographical measures set as the covariates. When the F-ratio was significant, Bonferroni's post hoc test was employed to identify the mean differences. Effect sizes were determined as partial eta squared (η^2_p). The level of significance was set at P<0.05. ANCOVA (Analysis of Covariance) is a method used in statistical analysis to control the effect of covariates and reduce intergroup variation (Önder, 2018).

Table 1. Descriptive statistics of the participants (Independent samples t test or χ^2 test)

Variable	Participants with sacralization (n=85)	Asymptomatic participants (n=56)	P
Age	55.85±12.41	46.53±14.66	<0.001
Body mass index (kg/m^2)	26.14±2.13	25.17±4.34	0.078
Female (%)	35 (41.17)	29 (51.78)	0.231
Castelvi type (%)			
1a	13 (15.29)	-	-
1b	10 (11.76)	-	-
2a	15 (17.64)	-	-
2b	36 (42.35)	-	-
3a	3 (3.52)	-	-
3b	8 (9.41)	-	-

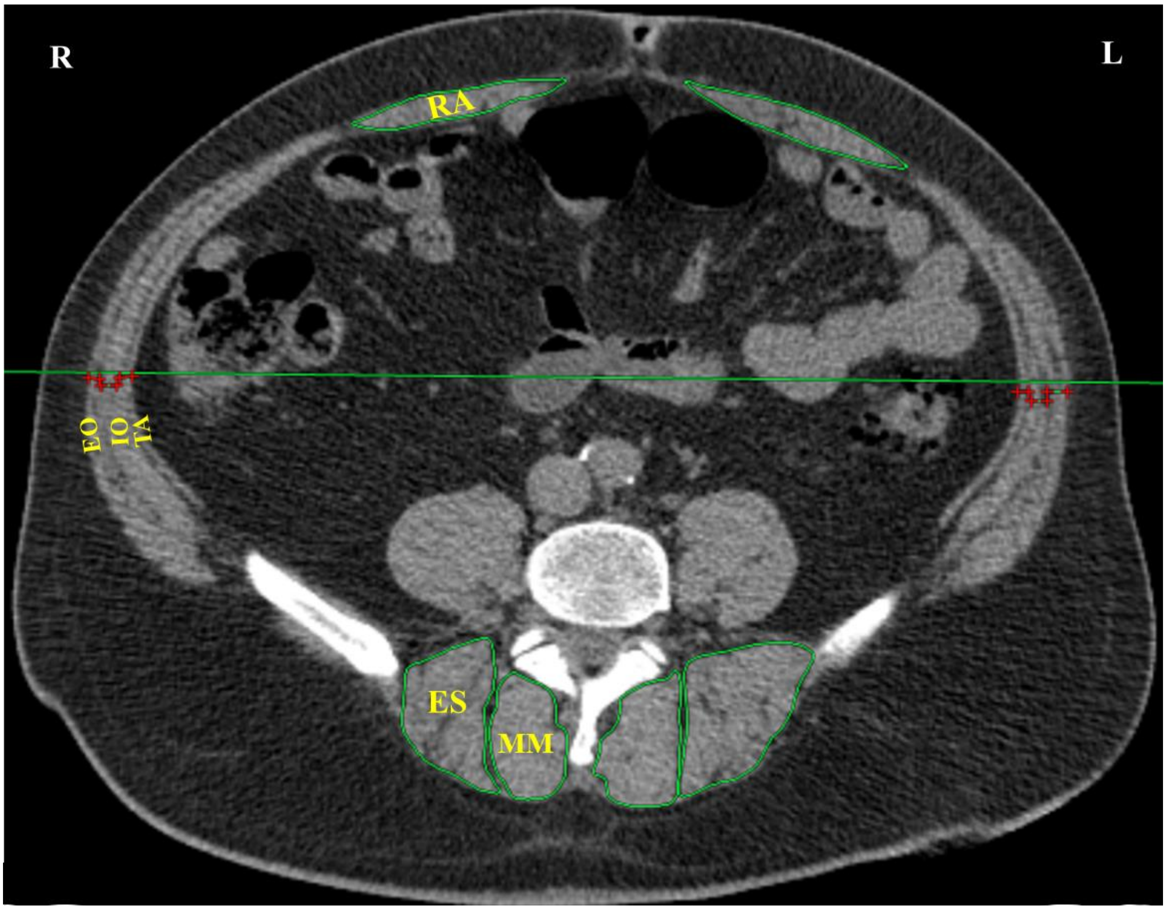

Figure 1. Measurements of muscles sizes (An axial CT image at L4-L5 level. EO= external abdominal oblique muscle, IO= internal abdominal oblique muscle, TA= transversus abdominis muscle, RA= rectus abdominis muscle, MM= multifidus lumborum muscle, ES= erector spina muscle).

3. Results

A total of 141 participants with (n=85) and without (n=56) sacralization were included in the study. Descriptive characteristics of the participants are presented in Table 1. There was no any significant difference between the two groups in terms of baseline characteristics except for age (P>0.05). The mean of age were higher in the sacralization group (P<0.001).

ANCOVA revealed a side effect regarding cross-sectional areas of rectus abdominis muscle [(P=<0.001; η^2_p=0.085)] and erector spinae muscle [(P=0.005; η^2_p=0.055)] in terms of L1-2 measurements. But, there is no any significant group*side interaction effect regarding cross-sectional areas of muscles in terms of two groups in L1-L2 (Table 2).

ANCOVA revealed a side effect regarding cross-sectional areas of rectus abdominis muscle [(P=<0.001; η^2_p=0.107)], internal oblique muscle [(P=0.026; η^2_p=0.035)], and erector spinae muscle [(P=0.003; η^2_p=0.062)] in terms of L4-L5 measurements. But, there is no any significant group*side interaction effect regarding cross-sectional areas of muscles in terms of two groups in L4-L5 (Table 2).

Lastly, ANCOVA revealed a both side effect [(P=0.020; η^2_p=0.038)] and group*side interaction effect [(P=0.010; η^2_p=0.049)] regarding length of the L5 transverse process. This was higher in the sacralization group (Table 2).

4. Discussion

In this study, based on cross-sectional CT imaging from adults with (n=85) and without (n=56) sacralization, the dimensions of the multifidus (MM), erector spina (ES) and abdominal muscles at the L1–2 and L4–5 intervertebral discus levels were evaluated. The data we obtained revealed that the muscle sizes of the individuals with sacralization were similar to the muscle sizes of the individuals in the control group. In addition, according to Castellvi classification, Type 2b was the most common type of sacralization in our study at 42.35%.

Sacralization, a congenital vertebral anomaly, is a frequently encountered condition in the general population (Jancuska et al., 2015). The relationship between LSTV and low back pain (LBP) is well known and studies on paraspinal muscle dimensions are quite extensive (Peterson et al., 2005; Apaydin et al., 2019; Ulger and Illeez, 2020). However, it is a known fact that the reduced muscle mass in the lumbar region not only affects the global sagittal alignment of the spine but also plays a role in the development of LBP (Ambegaonkar et al., 2014; Uçar et al., 2021).

Table 2. Comparison of cross-sectional areas of muscles and length of the L5 transverse process between two groups

	Participants with sacralization			Asymptomatic participants			2 x 2 ANCOVA	
	Right	Left	p[1]	Right	Left	p[1]	Side p^2 (η^2p)	Group*Side p^2 (η^2p)
L1-L2 measurements								
Rectus abdominis muscle	5.25±1.99	5.37±1.91	0.745	4.90±1.40	5.11±1.36	0.322	<.001 (.085)*	0.336 (0.007)
External oblique muscle	5.39±1.18	5.42±1.18	0.893	6.26±1.20	6.25±1.18	0.956	.551 (.003)	0.573 (0.002)
Internal oblique muscle	6.27±1.36	6.26±1.34	0.968	7.08±1.23	7.05±1.27	0.875	.677 (.001)	0.688 (0.001)
Transversus abdominis muscle	3.66±0.83	3.63±0.87	0.852	4.31±0.84	4.32±0.79	0.936	.711 (.001)	0.513 (0.003)
Lumbar multifidus muscle	9.88±2.23	9.93±2.23	0.905	10.88±3.08	11.17±2.85	0.524	.203 (.012)	0.367 (0.006)
Erector spinae muscle	10.02±2.24	9.86±2.32	0.711	11.29±2.55	11.15±2.50	0.718	.005 (.055)*	0.888 (<0.001)
L4-L5 measurements								
Rectus abdominis muscle	5.71±2.23	5.85±2.16	0.736	5.28±1.50	5.46±1.51	0.436	<.001 (.107)*	0.657 (0.001)
External oblique muscle	5.28±1.32	5.32±1.31	0.872	6.55±1.40	6.57±1.36	0.924	.379 (.006)	0.737 (0.001)
Internal oblique muscle	6.34±1.56	6.29±1.52	0.863	7.92±1.62	7.85±1.53	0.772	.026 (.035)*	0.700 (0.001)
Transversus abdominis muscle	3.20±0.94	3.19±0.91	0.954	4.32±0.79	4.35±0.74	0.798	.554 (.003)	0.533 (0.003)
Lumbar multifidus muscle	8.89±2.15	8.94±2.21	0.903	10.43±2.21	10.30±2.21	0.701	.488 (.003)	0.148 (0.015)
Erector spinae muscle	9.49±1.92	9.34±1.93	0.680	11.04±1.92	10.95±1.82	0.754	.003 (.062)*	0.431 (0.004)
Length of the L5 transverse process	20.62±4.08	22.63±4.11	0.001	15.00±1.91	15.17±2.11	0.582	.020 (.038)*	0.010 (0.049)*

p[1]: Independent samples t test results for within-group side comparisons; p^2: two-way repeated measures analysis of covariance with a mixed model. Figures in parentheses are effect sizes partial eta squared (η^2p).

In addition, the muscles of the anterior-lateral abdominal wall play an important role in the spine stability (Hodges and Richardson, 1997). Studies investigating the relationship between LSTV and both paraspinal and abdominal muscle sizes are limited, regardless of LBP (Becker et al., 2021). Therefore, in our study, images of patients who applied with pre-diagnoses such as urinary system stones, intestinal and visceral organ pathologies other than LBP, were examined for sacralization, and paraspinal and abdominal muscle sizes of individuals with sacralization and those in the control group were analyzed and compared.

The presented study differs from previous studies that showed individuals with LSVT to have atrophic musculature. Our data showed that there were statistically similarity in the paraspinal and abdominal muscles between the both groups. There could be two reasons for this. First, hypomobility at the sacralization level is compensated by hypermobility of segments above this level. This hypermobility may have caused individuals with sacralization to have similar muscle sizes to the control group, contrary to expectations, as it required more muscular workload. Second, most of the studies on this subject were conducted by examining the images of patients with LBP (Peterson et al., 2005; Apaydin et al., 2019; Ulger and Illeez, 2020). Today, the importance of paraspinal muscle quality in patients with low back pain is widely accepted. Muscle atrophy itself may play an important role in the pathogenesis of LBP. Therefore, studies on images taken for LBP may not only reflect the characteristics of individuals with sacralization. However, a recent study of 46 patients with LSTV reported a reduction in muscle sizes (Becker et al. 2021).

Our study revealed a side effect regarding cross-sectional areas of RA and ES in terms of L1-2 measurements. Also revealed a side effect regarding cross-sectional areas of RA, IO and ES in terms of L4-L5 measurements. This corroborates the studies of Becker et al. showing that individuals with LSTV have a different muscle load than the control group.

Our study has some limitations. First, because it was a retrospective study, we could not analyze clinical findings such as pain, activity limitation, and spasm. This prevented us from separating symptomatic and asymptomatic individuals. Second, morphological and degenerative changes in the facet or disc and fat changes in the muscles were not analyzed. Finally, we would like to point out that the sample size of our study is low. This may affect the statistical significance level of the results.

5. Conclusion

In conclusion, in our analyzes of CTs taken for different reasons, independent of LBP, we determined that sacralization did not have a significant effect on the paravertebral and abdominal muscles sizes of the individual. In order to shed light on the subject, studies with wider participation, including patient symptoms, are required.

Author Contributions

The percentage of the authors contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	İ.U.	F.Ç.	C.K.	S.Ç.
C	40	40	10	10
D	40	40	10	10
S	30	30	30	10
DCP	35	35	20	10
DAI	30	30	30	10
L	50	30	10	10
W	70	10	10	10
CR	20	50	10	20
SR	80	10	5	5
PM	30	50	10	10
FA	30	50	10	10

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Approval/Informed Consent

This study was approved by Ethics Committee of Niğde Ömer Halis Demir University (approval date: December 14, 2021, protocol code: 2021/108) and conducted in accordance with the principles of the Declaration of Helsinki.

References

Ambegaonkar JP, Mettinger LM, Caswell SV, Burtt A, Cortes N. 2014 Relationships between core endurance, hip strength, and balance in collegiate female athletes. Int J Sports Physical Ther, 9(5): 604.

Apaydin M, Uluc M, Sezgin G. 2019. Lumbosacral transitional vertebra in the young men population with low back pain: anatomical considerations and degenerations (transitional vertebra types in the young men population with low back pain). La Radiol Medica, 124(5): 375-381.

Becker L, Ziegeler K, Diekhoff T, Palmowski Y, Pumberger M, Schömig F. 2021. Musculature adaption in patients with lumbosacral transitional vertebrae: a matched-pair analysis of 46 patients. Skeletal Radiol, 50(8): 1697-1704.

Carrino JA, Campbell PD, Lin DC, Morrison WB, Schweitzer ME, Flanders AE, Vaccaro AR. 2011. Effect of spinal segment variants on numbering vertebral levels at lumbar MR imaging. Radiology, 259(1): 196-202.

Castellvi AE, Goldstein LA, Chan DP. 1984. Lumbosacral transitional vertebrae and their relationship with lumbar extradural defects. Spine, 9(5): 493-495.

Dar G, Peled N. 2014. The association between sacralization and spondylolisthesis. Anatomical Sci Int, 89(3): 156-160.

Hinterdorfer P, Parsaei B, Stieglbauer K, Sonnberger M, Fischer J, Wur G. 2010. Segmental innervation in lumbosacral transitional vertebrae (LSTV): a comparative clinical and intraoperative EMG study. J Neurol Neurosurg Psychiatry, 81(7): 734-741.

Hodges PW, Richardson CA. 1997. Contraction of the abdominal muscles associated with movement of the lower limb. Physical Ther, 77(2): 132-142.

Hughes RJ, Saifuddin A. 2006. Numbering of lumbosacral transitional vertebrae on MRI: role of the iliolumbar ligaments. AJR Am J Roentgenol, 187(1): 59-65.

Jancuska JM, Spivak JM, Bendo JA. 2015. A review of symptomatic lumbosacral transitional vertebrae: Bertolotti’s syndrome. Int J Spine Surg, 9: 42.

Önder H. 2018. Nonparametric statistical methods used in biological experiments. BSJ Eng Sci, 1(1): 1-6.

Paik NC, Lim CS, Jang HS. 2013. Numeric and morphological verification of lumbosacral segments in 8280 consecutive patients. Spine, 38(10): 573-578.

Peterson CK, Bolton J, Hsu W, Wood A. 2005. A cross-sectional study comparing pain and disability levels in patients with low back pain with and without transitional lumbosacral vertebrae. J Manipulative Physiol Ther, 28(8): 570-574.

Uçar İ, Batın S, Arık M, Payas A, Kurtoğlu E, Karartı C, Unur E. 2022. Is scoliosis related to mastication muscle asymmetry and temporomandibular disorders? A cross-sectional study. Musculoskeletal Sci Pract, 58: 102533.

Uçar İ, Karartı C, Cüce İ, Veziroğlu E, Özüdoğru A, Koçak FA, Dadalı Y. 2021. The relationship between muscle size, obesity, body fat ratio, pain and disability in individuals with and without nonspecific low back pain. Clin Anatomy, 34(8): 1201-1207.

Ulger FEB, Illeez OG. 2020. The effect of lumbosacral transitional vertebrae (LSTV) on paraspinal muscle volume in patients with low back pain. Acad Radiol, 27(7): 944-950.