A Comparison of the Abdominal and Lumbar Multifidus Muscle Size in Patients With Lumbar Spondylolisthesis and Healthy Patients at Rest and During Contraction Using Ultrasonography

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Abstract

Objective: Using ultrasonography, this study investigated the abdominal and lumbar multifidus muscle size in patients with lumbar spondylolisthesis compared with healthy patients at rest and during contraction.

Methods: This research was a nonexperimental, analytic case-control study. Ultrasound imaging was used to assess the thickness of the abdominal and lumbar multifidus muscles in 25 healthy patients and 25 patients with spondylolisthesis. For the purpose of this study, both men and women, aged 30 to 70 years, were recruited from physiotherapy clinics affiliated with the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. Measurements were taken at rest and during contraction.

Results: There was a significant difference in abdominal and lumbar multifidus muscle size between the healthy and spondylolisthesic groups, both at rest and contraction ($P < .05$ in all instances). No significant difference was found between the right and left for all measurements ($P > .05$).

Conclusion: Patients with spondylolisthesis had smaller stabilizer muscle thickness at rest and during contraction compared with the healthy group. (2018;41:691-697)

Key Indexing Terms: *Spondylolisthesis; Abdominal Muscles; Ultrasonography; Paraspinal Muscles*

Introduction

Lumbar spine stability is reported to be an important factor in patients with low back pain. Panjabi[1] (1992) proposed a model of spinal stability that seems to be a result of coordination among 3 major systems: active, passive, and neural. Lumbar segmental instability constitutes a subgroup of patients with chronic nonspecific low back pain.[2] Panjabi proposed that in lumbar segmental instability, stiffness in a lumbar movement segment decreases and results in an increased range of motion, leading to the painful condition. He proposed that spinal instability was a factor in reducing the capacity of the spinal stabilization system to maintain the neutral zone in the physiological limits. The increased range of the neutral zone is an important measure of spinal stability, followed by intersegmental injury, intervertebral disc degeneration, and muscle weakness.[3]

One of the elements in spinal stability is the active element, muscles,[1] which were divided into global and local muscles by Bergmark[4] (1989). Global muscles provide general stability of the trunk, and local muscles provide segmental stability.[4] In a patient with spondylolisthesis or spondylolysis in which the integrity of the passive stability structures is at risk, the neuromuscular

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system plays an important role in providing segmental dynamic stability. Evidence suggests that in lumbar instability, the transverse abdominis (TrA) muscle and lumbar multifidus (LM) are affected[5] and any type of disruption in the normal function of the local muscles results in dysfunction of the stabilizing system and segmental instability of the lumbar spine, resulting in pain and functional disability for patients.[6]

There are different approaches for evaluating the various components and characteristics of muscles in healthy people and patients with musculoskeletal disorders, including electromyography,[7-10] magnetic resonance imaging[11-13] and ultrasonography.[14-18] Among these, sonography is a common and noninvasive technique that is used widely for evaluating the morphology (shape and size) of the muscles and connective tissues.[19-21]

Lumbar stabilizer muscles provide dynamic stability and segmental control of the spine. However, if these muscles experience weakness, atrophy, or dysfunction, the spinal stability is at risk and may lead to instability, which can cause an increase in the intersegmental movement and eventually spondylolisthesis. Given the high prevalence of spondylolisthesis (2%-6%)[22] and the role of the muscles in lumbar spinal stability, evaluation of the lumbar stabilizer muscles in patients with spondylolisthesis is of great value.

Using ultrasonography, this study aimed to investigate the abdominal and LM muscle size in patients with lumbar spondylolisthesis compared with healthy patients at rest and during contraction.

Materials and Methods

After obtaining ethical approval (received from the medical ethics board at the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; IR.USWR.REC.1393.192) and through a nonexperimental, analytic, case-control study, 25 healthy patients and 25 patients with spondylolisthesis aged 30 to 70 years were recruited from physiotherapy clinics affiliated with the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. Data were collected from March to September 2016. The sample size was estimated based on the information received from a pilot study. According to the standard deviation (SD) of muscle size in the control group = 0.07, the SD of muscle size in the experimental group = 0.09, the average of muscle size in the control group = 0.61, and the average of muscle size in the experimental group = 0.34; 25 patients were needed for the purpose of this study. Demographic characteristics of the participants are shown in Table 1.

Patients who experienced ischemic or degenerative spondylolisthesis were included through clinical and radiographic findings (diagnosed by a spinal surgeon). Healthy patients aged between 30 and 70 years old with no history of low back pain also were recruited from staff of the department of physiotherapy and physiotherapy clinics.

Table 1. *Demographic Data of the Participants in Each Group (Mean ± SD)*

Variables	Healthy Group (n = 25)	Spondylolisthesis Group (n = 25)
Age (y)	51.20 ± 10.69	57.20 ± 11.74
Weight (kg)	72.52 ± 13.81	76.76 ± 11.37
Height (m)	1.68 ± 0.09	1.64 ± 0.09
BMI (kg/m^2)	25.65 ± 3.87	26.71 ± 3.89

BMI, body mass index; *SD*, standard deviation.

Participants were excluded if they had any history of sacroiliac dysfunction, scoliosis, or other structural defects in the spine; respiratory and rheumatoid disease; neurological disease; fracture or dislocation in the lumbar region; malignancies; metabolic diseases; and any sensitivity to the gel.[22] All participants were given written information about the purposes and the procedures of the study, and a written consent was taken if they agreed to participate. Then a questionnaire concerning demographic data was completed.

Sonographic evaluation of the abdominal muscles (TrA, internal oblique, external oblique) and LM was made by a portable sonography device model LEO-3000D1 (XuZhou LEO Medical Equipment Co Ltd, Xuzhou, China) with linear and curvilinear probes. To assess abdominal muscles, individuals were asked to lie in a supine hook-lying position. The linear probe was placed vertically between the 12th rib and iliac crest over the anterolateral abdominal wall.[14,23,24] Measurement of the thickness of the abdominal and LM muscles was performed at rest and during contraction (Figs 1 and 2). Abdominal muscles were assessed during the abdominal drawing-in maneuver.[23,25] To monitor the contraction of these muscles, a pressure biofeedback was used under the posterior superior iliac spine and the base pressure of the device was set to 40 mmHg.[26] At the end of expiration, a clear image of the thickness of muscles was fixed and recorded. LM muscle size was measured in the prone position, and 1 or 2 pillows were placed under the pelvis to reduce lumbar lordosis. Spinous processes from L4 to S1 were marked by the examiner with a marker. The transducer was placed transversely over the spinous processes of the vertebral level being measured.[22,27] Participants were instructed to lift each of the lower limbs separately from the back at the end of the exhalation to measure the size of muscles in the contraction state.[28] In this situation, imaging was performed from the LM muscle at rest and during contraction.

Statistics

All statistical analyses were conducted using SPSS version 22 (IBM Corp, Armonk, New York). Quantitative variables were described as mean and SD. The normality

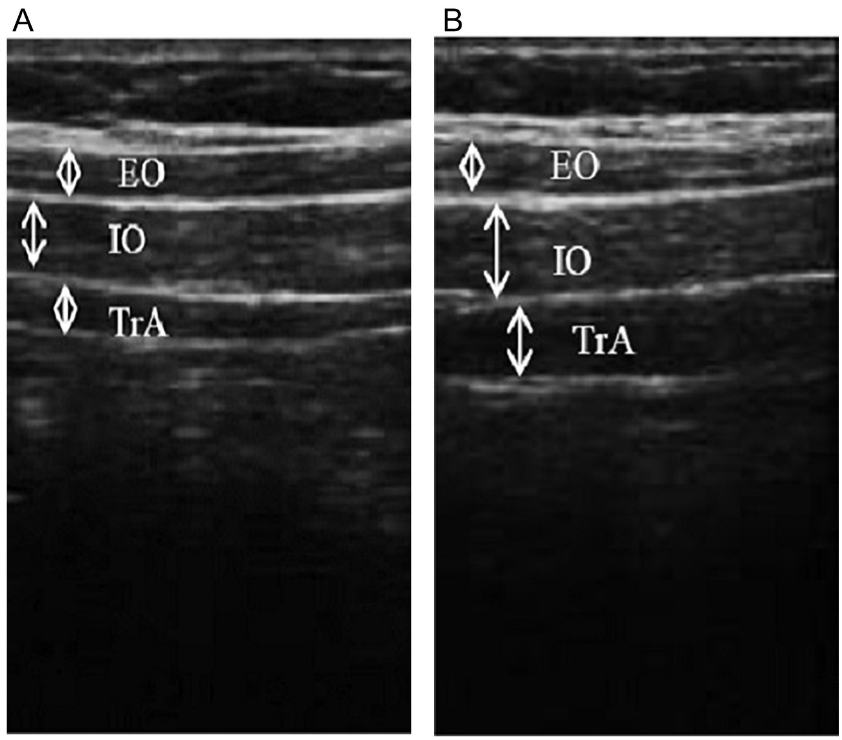

Fig 1. *Abdominal muscle at rest (A) and during contraction (B).* EO, *external oblique;* IO, *internal oblique;* TrA, *transversus abdominis.*

distribution of quantitative measurements was tested by the Kolmogorov-Smirnov test. Differences in the cross-sectional area and thickness of the muscles between the groups were assessed with an independent-sample *t* test. Also, differences between variables in the right and left body side in each group were assessed using a paired *t* test. Finally, the Pearson correlation (r) test was applied to analyze the association. Statistical significance was set at $P < .05$.

Results

Mean and SD of the abdominal and LM muscle size for both healthy and patient groups at rest and during contraction are shown in Tables 2 and 3. There was a significant difference in abdominal muscle thickness and LM muscle size for each side of the body at rest and during contraction between healthy participants and patients with spondylolisthesis ($P < 0.05$ in all instances).

Comparison between the left and right TrA and LM muscles in both groups demonstrated no significant difference between the 2 sides ($P > 0.05$ in both cases). Data are shown in Table 2 and 3.

Discussion

This is the first study comparing the size of the abdominal and LM muscles between healthy people and patients with spondylolisthesis at rest and during contraction. The results of the present study demonstrated the same results when compared with similar studies in patients with low back pain. In studies investigating differences in the size of LM muscles between healthy group and patients with low back pain, the size of the LM muscle was reported to be smaller in patients compared with healthy people. Wallwork et al[29] (2009) reported that the cross-section of the multifidus muscle at the L5 level in patients with low back pain was considerably smaller than in healthy patients. Hides et al[27] (2008) also demonstrated the same result in another study with a similar design. They indicated that the multifidus muscle at L4 and L5 levels is larger in a healthy group.[27] In another study conducted by Hides et al[27] (2008), atrophy of the LM muscle was observed in cricket players who experienced low back pain at the L4 level.[30] The result of the current study is in the same direction as the previous studies, and atrophy of the LM muscle was observed in patients with spondylolisthesis.

Kim et al[31] (2013) demonstrated atrophy of the TrA muscle in patients with chronic low back pain. The results of the study conducted by Whittaker et al[32] (2013) also showed a significant difference between the thickness of the abdominal muscles among 2 groups of healthy people and patients with lumbopelvic pain. The results of these studies are also in agreement with the findings of the current study.

Recent studies indicate that abdominal and LM muscles are involuntarily inhibited in patients with chronic low back

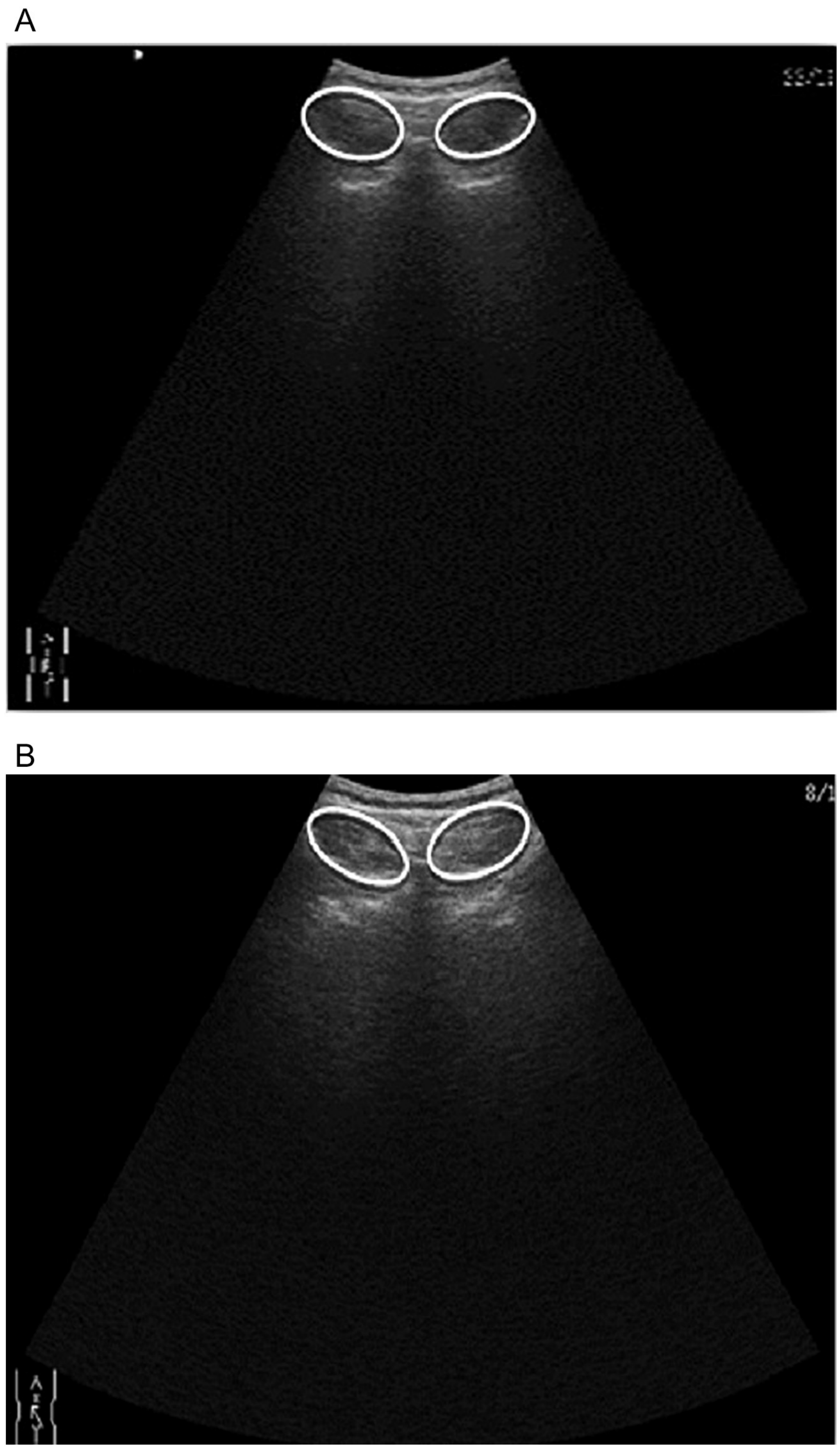

Fig 2. *Lumbar multifidus muscle at rest (A) and during contraction (B).*

pain and the stabilizing function of these muscles is affected. Tonic fibers of these muscles have a supportive postural antigravity effect.[33,34] The size of the type II fibers is reported to be reduced in patients with low back pain.[35]

Deep muscles also have a role in controlling the spine in the dynamic conditions, thus they have a great effect on controlling the intervertebral movements.[36,37] On the other hand, the strategy of controlling the trunk muscles is altered

Table 2. *Mean Thickness Measurements of Abdominal and Lumbar Multifidus in Each Side at Rest Using Ultrasound*

Muscle (Rest)	Healthy Group				Spondylolisthesis Group				*P* Value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Right CSA (cm^2)	6.69	0.29	3.20	7.69	4.30	0.25	2.94	5.82	.007
Left CSA (cm^2)	6.43	0.31	4.19	6.49	4.47	0.26	2.89	5.28	.006
Right A-P (cm)	2.13	0.12	0.99	2.44	1.71	0.12	0.64	2.12	.018
Left A-P (cm)	2.28	0.13	1.12	2.56	1.78	0.12	0.69	2.03	.011
Right M-L (cm)	2.89	0.11	1.47	3.03	2.48	0.14	1.36	2.85	.016
Left M-L (cm)	3.03	0.13	1.46	3.36	2.51	0.15	1.36	3.03	.019
Right TrA (cm)	0.66	0.09	0.32	0.79	0.28	0.09	0.21	0.62	.004
Left TrA (cm)	0.65	0.07	0.32	0.69	0.25	0.10	0.23	0.64	.003
Right IO (cm)	0.99	0.23	0.54	1.35	0.53	0.14	0.44	1.04	.005
Left IO (cm)	0.97	0.25	0.52	1.54	0.62	0.19	0.48	1.12	.009
Right EO (cm)	0.76	0.10	0.40	0.85	0.35	0.14	0.12	0.66	.013
Left EO (cm)	0.77	0.08	0.40	0.80	0.32	0.17	0.14	0.65	.011

A-P, anterior-posterior; *CSA*, cross-sectional area; *EO*, external oblique; *IO*, internal oblique; *Max*, maximum; *Min*, minimum; *M-L*, mediolateral; *SD*, standard deviation; *TrA*, transversus abdominis.

Table 3. *Mean Thickness Measurements of Abdominal and Lumbar Multifidus in Each Side During Contraction Using Ultrasound*

Muscle (Rest)	Healthy Group				Spondylolisthesis Group				*P* Value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Right CSA (cm^2)	6.86	0.33	3.31	7.28	4.83	0.25	3.08	6.93	.001
Left CSA (cm^2)	6.84	0.31	3.33	7.02	4.89	0.27	2.97	5.13	.003
Right A-P (cm)	2.68	0.13	1.58	3.13	2.18	0.11	1.69	2.90	.009
Left A-P (cm)	2.38	0.12	1.79	3.00	1.83	0.11	1.69	3.06	.007
Right M-L (cm)	2.91	0.12	1.00	3.09	2.49	0.12	1.51	3.07	.014
Left M-L (cm)	3.13	0.12	1.59	3.77	2.69	0.14	1.41	2.94	.016
Right TrA (cm)	0.78	0.10	0.41	0.89	0.39	0.09	0.28	0.74	.002
Left TrA (cm)	0.81	0.09	0.44	0.85	0.38	0.11	0.31	0.74	.003
Right IO (cm)	1.11	0.26	0.64	1.52	0.75	0.18	0.52	1.23	.01
Left IO (cm)	1.14	0.29	0.71	1.75	0.81	0.18	0.54	1.24	.006
Right EO (cm)	0.87	0.12	0.46	1.05	0.43	0.13	0.21	0.74	.009
Left EO (cm)	0.87	0.10	0.51	1.01	0.45	0.11	0.24	0.72	.014

A-P, anterior-posterior; *CSA*, cross-sectional area; *EO*, external oblique; *IO*, internal oblique; *Max*, maximum; *Min*, minimum; *M-L*, mediolateral; *SD*, standard deviation; *TrA*, transversus abdominis.

and the activity of the deep muscles is disrupted (delayed activity and diminishment in tonic activity), and atrophy will be apparent in these muscles.[38]

Clinical Relevance

The results of the present study seem to be helpful for clinicians and researchers to identify the level of lumbar and abdominal muscle involvement in patients with spondylolisthesis based on their muscle size. Therefore, different treatment programs can be designed to train stabilizer muscles for such patients. According to the findings of the present study, it also might be possible to monitor the effectiveness of different interventional programs in patients with spondylolisthesis using ultrasound.

Limitations

There were a few limitations in this study, such as difficulty in accessing patients with spondylolisthesis and also the inability for the researcher to be blinded to the patients' condition. The data collected about the size of the abdominal and LM muscles in patients with spondylolisthesis may help in understanding more about the role of muscles in spondylolisthesis. Further research is also possible to assess the effect of different interventions to compensate for the atrophy of the stabilizer muscles of the spine in patients with spondylolisthesis.

Conclusion

According to the results of the present study, it seems that the size of the abdominal and LM muscles at rest and during contraction was reduced in patients with spondylolisthesis. There was no significant difference between the 2 sides (right and left) at rest and during contraction in both groups. However, further large-scale studies are recommended to support the findings of this study.

Funding Sources and Conflicts of Interest

This study was supported financially by the University of Social Welfare and Rehabilitation Sciences. No conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): A.S., M.A.M.B., N.R., S.A.B.
Design (planned the methods to generate the results): A.S., M.A.M.B., N.R., S.A.B.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): A.S., M.A.M.B., N.R., S.A.B.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): A.S., M.A.M.B., N.R., S.A.B.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.S., M.A.M.B., N.R.
Literature search (performed the literature search): A.S., M.A.M.B., N.R.
Writing (responsible for writing a substantive part of the manuscript): A.S., M.A.M.B., N.R., S.A.B.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): A.S., M.A.M.B., N.R., S.A.B.

Practical Applications

- Patients with spondylolisthesis seem to have smaller abdominal muscle size compared with healthy patients.
- Lumbar multifidus muscle size was found to be reduced in patients with spondylolisthesis compared with healthy patients.
- It seems that stabilizer muscles at the right and left sides are similarly affected in patients with spondylolisthesis.

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