

Research Paper: Lateral Abdominal Muscles Asymmetry in Female Patients With Chronic Non Specific Unilateral Low Back Pain Practicing Hollowing Exercises



Maryam Zolghadr¹, Sedighe Kahrizi^{2*}, Alireza Soltanian³

1. MSc., Department of Physiotherapy, School of Medical Sciences, Tarbiat Modares University, Tehran, Iran.

2. Associate Professor, Department of Physiotherapy, School of Medical Sciences, Tarbiat Modares University, Tehran, Iran.

3. Associate Professor, Department of Biostatistics and Epidemiology, School of Health, Hamadan University of Medical Sciences, Hamadan, Iran.



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ABSTRACT

Introduction: With regard to unilateral pain in some patients with low back pain (LBP), it is advisable to evaluate asymmetrical thickness of lateral abdominal muscles. This study aimed to compare abdominal muscle thickness asymmetry in patients with non specific unilateral LBP during rest and practicing several stabilizing exercises with hollowing maneuver.

Materials and Methods: This research has a case-control design. Sixteen female subjects with left and right unilateral LBP and 8 healthy subjects participated in this study. Internal oblique, external oblique and transversus abdominal muscles thickness were evaluated by ultrasound imaging technique in both sides of the subjects' bodies during rest and hollowing maneuver with 3 stabilizing exercises; bridging, four point kneeling and abdominal crunch.

Results: According to the findings, abdominal muscle thickness asymmetry during exercises was more than resting position in two groups but it is not statistically significant. Also, no significant difference was seen between case and control groups regarding abdominal muscle thickness asymmetry.

Conclusion: Considering the appearance of asymmetry in healthy subjects, it seems that asymmetry in abdominal muscles cannot be interpreted as pathologic phenomena in LBP subjects.

1. Introduction

The osteoligamentous spine without its musculature is inherently unstable. Stability of passive structures is provided by active structures. This active system comprises the muscles that act superficially

(global muscles), the muscles that act directly on the spine (local muscles) and peripheral and central nervous system that control muscles. The evolution of the spinal stability model has drawn much research, particularly on the functional group of (deep) muscles (transversus abdominis [TrA], and lumbar multifidus) with segmen-

* Corresponding Author:

Sedighe Kahrizi, PhD

Address: Department of Physiotherapy, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran.

Tel: +98 (21) 82884511

E-mail: kahrizis@modares.ac.ir

tal patterns of attachment to the lumbar region contributing in keeping intersegmental stiffness.

Based on the evidence, spinal muscles provide stability, while muscle recruitment patterns significantly affect loading on the intervertebral joints. Thus in theory, imbalanced muscle activation due to disoriented timing can incorrectly load the spine and induce low back pain (LBP) and musculoskeletal injury [1]. Growing evidence has shown significant dysfunction in deep stabilizer muscles in patients with chronic LBP [2].

Referring to a recent study, about 34% of people who experienced acute LBP would suffer from recurrent episodes. There are many theories on why some patients experience these episodes while others do not. One possible reason is the loss of normal motor control of the deep muscles in the lumbar spine [3]. According to the results of recent studies, multifidus muscles of patients with unilateral LBP are asymmetric and this muscle in the pain side is thinner. In McDonald concluded " the onset of the short fibers (multifidus) of the deep back muscle relative to the arm muscle and deltoid occur later in people with recurrent LBP compared to the healthy participants.

Since in McDonald study , delay was greater in painful side than the non painful side of back, Motor control dysfunction and lack of local muscle protection is logical. so following the continuity of unilateral loss in muscle thickness and subsequently asymmetry, can cause of pain episodes in recurrent LBP. Hides (2011) study found a significant clinical relationship between transverse abdominis muscle and lumbar multifidus muscle in patients with chronic LBP [4]. So asymmetry of abdominal muscle thickness can be one of the probable causes of recurrent pain in patients with unilateral LBP. As recent studies indicate changes in "abdominal muscle onset latency or thickness" and "abdominal fascial slide" in patients with LBP, can be signs of motor control dysfunction or pain adaptation or both.

It was revealed that conventional (usual or routine) exercises is not effective on LBP syndrome relief. It sounds that we should design specific exercises to train stabilizer muscles for prevention of pain in the spinal column. This is the main reason of quantitative assessment of deep abdominal muscles. In this regard, one of the important problems is asymmetry of abdominal muscles activation during spinal stabilization exercises. Asymmetry of abdominal muscles is a more significant factor for lumbar region studies than absolute values of abdominal muscles activity [3]. Moreover, there may be a relationship between the painful side of unilateral LBP

and paraspinal muscles asymmetry on that side (side of less thickness).

Muscle asymmetry means that in one side, the muscle is thinner. In this regard, it is necessary to selectively activate deep abdominal muscles or private proprioceptive receptors, which are responsible of neuromuscular control and spinal stabilization for rebuilding a proper accurate pattern of muscle activation. Selective activation of spinal proprioception receptors can rebuild (restore) proper pattern of muscular feed forward response and concomitant reflex arcs [5]. Because accentuation of global muscles activation on compensatory patterns, master key (success key) in the re-activation of proper postural strategies, is "core muscles separate activation" and avoidance of voluntary co-contraction of global muscles [6].

A recent clinical trial indicates exercise therapy for deep trunk muscles control in acute and sub-acute LBP can restore symmetry of back muscles cross sectional area and reduce recurrence of LBP episodes [7]. Asymmetry of abdominal muscles in LBP patients has been already studied in resting position [8] and during hollowing or automatic task in healthy and involved participants [9-11] and there are several studies about various sports which involve body asymmetrically [12, 13]. Whereas exercise therapy is one of the efficient methods in rehabilitation of patients with LBP but it has not been studied with regard to abdominal muscles asymmetry and its changes in LBP patients during exercises compared to healthy people. This study aimed at examining the lateral abdominal muscles thickness in both sides of body in resting and during hollowing with three common exercises: bridging, quadruped position and abdominal crunch in non specific chronic unilateral LBP patients and to compare probably asymmetry magnitude between rest and exercise positions.

2. Materials and Methods

Our research was a quasi-experimental, cross-sectional, and case-control study that included 24 subjects in 3 groups of 8 female patients with left sided non specific chronic unilateral LBP, 8 female patients with right sided non specific chronic unilateral LBP and 8 healthy female subjects. Subjects in three groups were matched with respect to their sex, age, pain scale and Body Mass Index (BMI) (Table 1). Participants in the case groups had LBP that lasted for 3 months or LBP that occurred once in each 6 months. Their pain score was equal or more than 3 based on the Visual Analogue Scale (VAS) in the test day. The study participants were students and university staff and entered into the study after clinical examination

by the spine specialist in LBP. Healthy subjects comprised active non-athlete females without a history of back pain for 1 year or longer.

Exclusion criteria for all subjects were pain score more than 3 (based on VAS) on the experiment day, inability to learn and perform the hollowing maneuver, unwillingness to continue participation in the study, and having severe problems (dysfunctions) such as cardiovascular, respiratory, neurological, systemic and metabolic disease, malignancy, fractures, infections, radicular pain in lower extremities or history of spinal column and lower extremities surgery, pregnancy and abortion.

Before starting the intervention, the study procedure was explained to all participants and their consent forms were taken. Background data and demographic questionnaires were completed by the subjects. The Ethics Committee of Medical Research of Tarbiat Modares University approved the study and all procedures complied with the Declaration of Helsinki.

A rehabilitation imaging unit set in the B-B mode (HONDA ELECTRONICS HS 2100, Japan) with a 7.5-MHz linear probe (frequency range of 7-10 MHz) and central frequency of 7.5 MHz was used to measure abdominal muscle thickness. The measurement precision was 0.1 mm in muscle thickness of lateral abdominal muscles including transverse abdominis, internal oblique and external oblique on both sides of the body. Measured thickness of the lateral abdominal muscles with rehabilitative ultrasonography has been validated against reference standard such as MRI [14]. To record the images of the deep abdominal layers, the ultrasound transducer was transversely located across the abdominal wall over the anterior auxiliary line, midway between the 12th rib and the iliac crest [15].

Images were taken and saved at the end of the exhalation [9]. After recording images, the thickness of the muscles was measured as the distance between the edge of the internal fascia and external fascia, by unit caliper. To minimize error, measurement of muscle thickness was done at three points of muscle image length and their average was recorded as final thickness. Before starting the main tests of study, the pilot study was done on 8 subjects with recording three images for every position. Measurements and calculations demonstrated excellent reliability (ICC=0.96-0.98) of this method of measurement in one day.

Experiment positions

In the resting position, three voluntary activation of the lateral abdominal muscles were selected including performance of hollowing maneuver as 1. Bridging; 2. Four point kneeling; and 3. Abdominal crunch position. These positions were selected because of symmetrical activation of abdominal and low back key muscles including transverse abdominis, erector spine, lumbar multifidus, abdominal obliques and quadratus lumborum on both sides of the body as reported in the recent biomechanical and electrophysiological studies [14, 16-18].

Resting position

The subject was asked to lie supine, head in midline, arms beside the body, eyes to the roof and all parts of the body in symmetric position and breathe normally and calmly.

Abdominal crunch

lying supine, 60° knee flexion in both knee joints, arms crossed on chest and head and neck brought up until the inferior angle of the scapula was parted from the couch.

Table 1. Demographic characteristics of study participants

Row	Variable	Right Sided LBP n=8	Left Sided LBP n=8	Healthy Without LBP n=8
		Mean±SD	Mean±SD	Mean±SD
1	Age, y	28.85±4.41	4.13±29.25	2.34±27.14
2	Height, m	0.465±1.58	0.372±1.61	0.509±1.57
3	Weight, kg	5.20±54.41	5.58±56.25	4.03±53.00
4	Body Mass Index (BMI), kg/m ²	1.62±21.47	2.10±21.64	0.91±21.11
5	Experienced maximum pain	17.52±77.50	20.00±65.00	-

Bridging

The subject was asked to lie supine, knee flexed so that the legs were plumped to the couch, head in midline and arms beside the body and bring up her basin in order to extend lumbar area while breath normally [17].

Four point kneeling

quadruped position, shoulder, knee, hip and lumbopelvic joints on both sides of body 90° flexed with head in midline and line of sight to the front.

In order to induce asymmetry in voluntary contraction of abdominal muscles, the patients were asked to perform “abdominal hollowing” as above mentioned three test positions. Accurate performance of hollowing maneuver was instructed (educated) to all subjects by “pressure biofeedback” and vision-feedback of real-time ultrasound images. To avoid order effect, the images were obtained in a counterbalanced order that its validity was confirmed by Teyhen [19], thus all recordings were done in two trials.

One trial was done first from the left side and after a 3-second interval the next was done from the right side. In the second trial, first recording was done from the right side and next from the left side. Location of the probe and test positions for every subject and all trials were kept fixed via drawing signs on location. The asymmetry across body sides thickness measure and contraction index were determined using the Rankin et al. (2006) method, in which the absolute difference in values between right and left sides was expressed as a percentage of the smallest value recorded in either of the two sides [8].

Statistical analysis

Statistical analysis of the data was performed by SPSS 16. According to results of Kolmogorov Smirnov test, distribution of variables of the present study was normal. To check the reliability of the measurements between

two images of every position, the intraclass correlation coefficient test was done. One-way analysis of variance (ANOVA) was used to compare asymmetry values between the three groups and between resting position and each contraction position.

3. Results

Lateral abdominal muscle thickness in all study positions are presented in Tables 2, 3 and 4. Based on ANOVA test results, there is no significant difference between three groups with respect to the percentage of lateral abdominal muscle thickness asymmetry. In comparison of asymmetry values in resting position and contraction, increased asymmetry in contraction positions relative to the resting position is obvious, but these changes were not significant (Tables 5 and 6).

4. Discussion

Based on biomechanical models of spine study, spinal column is affected by abnormal patterns of muscle activation that eventually causes pain sensation. Asymmetry and weakness of muscle activation during vertebral column motions, may put spine in an unstable position which can even progress to nerve root involvement or abnormal loadings. Musculoskeletal dysfunctions can create instability and pain in the spinal column. Research studies on comparing muscle activation between patients with LBP and healthy people not only studied absolute levels of muscle activation, but also examined patterns of muscle activation. In the field of LBP studies, asymmetry is more significant than the absolute muscle thickness [3].

The present study aimed to assess lateral abdominal muscle thickness asymmetry in patients with chronic non specific unilateral LBP during rest as well as several exercises (contraction) which activate these muscles symmetrically. The study question was “does asymmetry decrease during exercises?” It was also assessed the relationship between pain location and asymmetry side

Table 2. Comparing the percentage of absolute asymmetry of transverse abdominis muscle (Mean±SD) between three participant groups

Variable	Control Group (Without LBP)	Right Sided LBP	Left Sided LBP	P
Resting position	7.32±8.16	16.01±15.38	14.91±16.54	0.45
Abdominal crunch exercise	19.51±16.59	19.51±22.45	9.87±5.14	0.43
Four point kneeling exercise	14.40±14.44	10.56±4.63	8.34±6.71	0.45
Bridging exercise	19.21±9.40	9.23±8.91	20.22±18.19	0.20

Table 3. Comparing the percentage of absolute asymmetry of internal oblique muscle (Mean±SD) between three participant groups

Variable	Control Group (Without LBP)	Right Sided LBP	Left Sided LBP	P
Resting position	13.00±14.82	14.87±10.48	14.13±8.82	0.95
Abdominal crunch exercise	20.87±16.11	21.00±12.22	11.84±10.56	0.30
Four point kneeling exercise	16.50±12.63	21.41±12.86	14.12±9.37	0.46
Bridging exercise	14.60±9.96	9.66±8.44	8.23±4.41	0.25

JMR

Table 4. Comparing the percentage of absolute asymmetry of external oblique muscle (Mean±SD) between three participant groups

Variable	Control Group (Without LBP)	Right Sided LBP	Left Sided LBP	P
Resting position	7.64±9.71	8.25±7.96	11.71±7.71	0.60
Abdominal crunch exercise	7.57±4.60	11.37±8.66	15.67±11.21	0.22
Four point kneeling exercise	18.35±22.50	17.58±11.89	7.19±11.11	0.31
Bridging exercise	13.44±10.25	15.13±7.42	17.83±11.96	0.69

JMR

in these patients. Although there are several studies on evaluation of abdominal muscle asymmetry in patients with LBP [7-9, 19, 20] but they have not compared this asymmetry and its changes during exercises between patients with LBP and healthy people, as well as the relationship of unilateral LBP and asymmetry of the lateral abdominal muscles. If there is such a relationship, it may

be necessary to design specific and efficient exercises for unilateral LBP rehabilitation.

According to the results, there were statistical significant difference between control and left sided LBP groups with regard to the degree of asymmetry of internal oblique muscle thickness, but it is not clinically significant because as mentioned in the related tables,

Table 5. Comparing percentage of asymmetry of lateral abdominal muscles between rest and contraction in each of exercise positions in LBP groups

Muscle	Abdominal Crunch	Bridging	Quadrapped
(TrA)	P=0.87	P=0.85	P=0.21
(IO)	P=0.62	P=0.12	P=0.36
(EO)	P=0.32	P=0.08	P=0.55

TrA: Transverse Abdominis muscle; IO: Internal Oblique muscle; EO: External Oblique muscle

JMR

Table 6. Comparing percentage of asymmetry of lateral abdominal muscles between rest and contraction in each of exercise positions in control group

Muscle	Abdominal Crunch	Bridging	Quardaped
(TrA)	P=0.06	P=0.07	P=0.11
(IO)	P=0.25	P=0.31	P=0.40
(EO)	P=0.98	P=0.17	P=0.34

JMR

this value for each of the groups is in the normal range that previously reported by Rankin et al. and Mannion (11%-25% in resting position, 14%-26% during hollowing exercises). Results of Megumi et al. (2011) despite reporting significant differences between LBP and healthy groups was consistent with our results because based on the precision of their digital data, asymmetry percentages for both groups were in normal range.

Roddy et al. compared abdominal muscles thickness asymmetry between patients with chronic LBP and healthy subjects and did not find any significant differences. Norman W. Gill reported that the results of his study about lateral abdominal muscle asymmetry in healthy (without LBP) single sided rowers are in normal range based on Rankin's figures.

Previous studies demonstrate a very close relationship between lumbar multifidus muscles asymmetry and LBP. And as regards close clinical relationship of lumbar multifidus and transverse abdominis muscle, asymmetry of the abdominal muscles can be assumed pathological. However, results of this study and recent research in this field indicate that: 1. Abdominal symmetry is very small (lower than 1 mm); and 2. Because of presence of this asymmetry in healthy people, it cannot be assumed pathologic, unlike lumbar multifidus muscles asymmetry that is present only in patients with LBP. Thus in evaluation of abdominal muscles thickness, asymmetry must be interpreted carefully. Because of small sample that was one of the limitations of the present study, we could not generalize the results suggesting future studies on unilateral LBP done on larger samples and by using electromyography.

Correlation tests indicate no significant relationship between pain location and the asymmetry side of unilateral LBP. Although there is no study on this possible relationship, in a similar study, Kiesel et al. (2008) reported decrease in transvers abdominis thickness on pain side during hollowing manoeuvre in an induced unilateral LBP subsequent to hypersaline infusion in erector spine muscle. Although their results are not comparable with this study because firstly they studied on male subjects and secondly they induced an acute LBP whereas our subjects were patients with chronic non specific LBP with VAS<3 on the experiment day. Hides et al. studied the relationship between lumbar multifidus muscles and pain side in patients with unilateral LBP and found it significant.

It means that lumbar multifidus muscle on pain side was thinner than the other side. Therefore, unlike abdominal muscles, asymmetry of these muscles is patho-

logic. This difference between multifidus and abdominal muscles, despite their close clinical relationship in lumbar stability, may be due to several reasons; Hides studied on lumbar disk herniation in subjects with LBP and in these patients the related nerves of the involved segments were affected too. Therefore multifidus muscle asymmetry due to painful side's muscle atrophy is limited to same segment also because multifidus is innervated by the posterior horn of nerve segment of the same involved vertebral segment, these muscles are exposed to denervation and atrophy. However, abdominal muscles are innervated by thoracic nerve roots so these muscles cannot be affected by not only lumbar nerve roots injuries in with structural LBP, but also in subjects with non specific LBP. In the meantime, this is simply a possibility and can be refuted by future research.

In this study, asymmetry in abdominal muscles thickness during exercise was greater than that in the resting position, i.e., exercise positions of the present study cannot restore symmetry of abdominal muscles. Several recent studies such as Mc Donald et al. (2009) suggested that stability exercises can decrease asymmetry in patients with LBP. According to results of the present study, single session exercises cannot decrease lateral abdominal muscles asymmetry. However, without further studies, we cannot discuss about the long term effect of these exercises on abdominal muscle asymmetry.

Lateral abdominal muscles thickness on each side of the body in healthy and patients with chronic non specific LBP was different and sometimes the difference was noticeable, but because of its presence in healthy people, it cannot always be assumed pathologic. Abdominal muscles thickness asymmetry side in patients with unilateral LBP does not follow a regular pattern. In other words, there is no significant relationship between pain side and atrophy side and every patient with LBP has her or his own individual "injury response." Single session exercises in this study cannot decrease or compensate asymmetry neither in healthy nor in subjects with LBP.

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Conflict of Interest

The authors declared no conflicts of interest.

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