Original Article

J Babol Univ Med Sci
Vol 18, Issu 11; Nov 2016. P:22-28

A Comparison between Symmetry of Abdominal Muscle Size in Healthy Adolescents and Adolescents with Low Back Pain

N. Rahmani(PhD)[1], M.A. Mohseni Bandpei (PhD)[2,3*], M. Salavati (PhD)[4], R. Vameghi (PhD)[1], I. Abdollahi (PhD)[4]

1.Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, I.R.Iran
2.Research Center on Aging, University of Social Welfare and Rehabilitation Sciences,Tehran, I.R.Iran
3.Department of Physiotherapy, Faculty of Paramedicine, University of Lahore, Lahore, Pakistan
4.Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences,Tehran, I.R.Iran

J Babol Univ Med Sci; 18(11); Nov 2016; PP: 22-8
Received: Jun 26th 2016, Revised: Jul 27th 2016, Accepted: Sep 27th 2016.

ABSTRACT

BACKGROUND AND OBJECTIVE: Low back pain (LBP) is a musculoskeletal disorder and a relatively common complaint. Muscles, as the most important stabilizers of the spine, are impaired in patients with LBP. The aim of this study is to compare the symmetry of abdominal muscle size in the dominant and non-dominant sides as well as the painful and painless sides between healthy adolescents and adolescents with LBP.

METHODS: This case-control study was conducted on 80 healthy adolescents and 80 adolescents with chronic nonspecific LBP, aged 15 to 18 years. Samples were chosen using convenience sampling method while being matched in terms of height, weight and body mass index. First, the demographic data were collected; then, their abdominal muscle size (transverse abdominus, internal oblique and external oblique) and intra-abdominal fat were measured by sonography.

FINDINGS: The difference in mean value and possibility value for transverse abdominus ($p=0.024$ and 0.189), internal oblique ($p=0.000$ and 0.861), external oblique ($p=0.031$ and 0.287) and intra-abdominal fat ($p=0.762$ and 0.081) was significant between the two groups in term of abdominal muscle size while the difference in intra-abdominal fat size was not statistically significant. Results also revealed a statistically significant difference in abdominal muscle size (except for external oblique and intra-abdominal fat) between the dominant and non-dominant sides ($p<0.05$) and between the painful and painless sides in adolescents with LBP ($p<0.05$).

CONCLUSION: The results of the present study demonstrated that abdominal muscle size in dominant and painful side is smaller than non-dominant and painless side.

KEY WORDS: *Adolescents, Abdominal muscle, Low back pain, Sonography*.

Please cite this article as follows:

Rahmani N, Mohseni Bandpei MA, Salavati M, Vameghi R, Abdollahi I. A Comparison between Symmetry of Abdominal Muscle Size in Healthy Adolescents and Adolescents with Low Back Pain. J Babol Univ Med Sci. 2016;18(11):22-8.

***Corresponding author: M.A. Mohseni Bandpei (PhD)**
Address: Research Center on Aging, University of Social Welfare and Rehabilitation Sciences,Tehran, I.R.Iran
Tel: +98 21 22180099
E-mail: Mohseni_Bandpei@Yahoo.com

[DOR: 20.1001.1.15614107.1395.18.11.3.7]
[DOI: 10.22088/jbums.18.11.22]

Introduction

Low back pain (LBP) is a musculoskeletal disorder and a relatively common complaint among patients referring to health care centers (1-3). According to the studies conducted in Iran, the prevalence of LBP is relatively high similar to other countries. Different prevalence rates of LBP have been estimated and reported for various ages and occupational groups in Iran, such that an annual prevalence of 17% among 11 to 14 years old students (4), a lifetime prevalence of 62% among nurses (5), 84% among teachers (6) and a lifetime prevalence of 84.8% among surgeons (7) have been reported. The major problem regarding patients with LBP is the unknown cause of this disorder. One probable source of pain is instability in the lower segments of the lumbar spine, which happens as a result of change in muscle control in this area (8). Two muscular systems (i.e. global and local) influence the lumbar spine. Local muscles play a minor role in body movement due to their short lever arms (9).

These muscles are responsible for stiffness control and intervertebral connection of lumbar segments. These muscles include multifidus, transverse abdominis and lower fibers of internal oblique (10). Evidence suggests that the movement of stabilizer muscles is delayed in patients with LBP. Muscle dysfunction may lead to a defect in motion control (11), delayed relaxation of muscles in response to the removal of load from them (12), decreased activity during operations, change in calling deep muscles (13) and morphologic changes such as decreased thickness, size and change in the shape of muscles (14-16). There are several ways to assess the lumbar stabilizer muscles including Electromyography (17 and 18), Magnetic resonance imaging (MRI) (19 and 20) and Sonography (21-23).

Among these techniques, measuring the dimensions of muscles using sonography as an inexpensive and non-invasive imaging technique provides the possibility to obtain information about the position of these muscles and their function. This can be proposed as a technique to assess the imbalances in this muscle group (15, 16). Studying the muscular symmetry is very helpful for the assessment of muscle atrophy, hypertrophy or the underlying pathological changes. Studies demonstrated that the abdominal muscles are symmetrical on both sides in healthy people with no history of LBP as the difference between the two sides is less than 1.5% (24). Moreover, no difference was observed in symmetry of abdominal muscles both at rest and during contraction (25). According to previous studies, asymmetry of abdominal muscles was observed in people with history of anatomic disorders such as scoliosis and unequal leg length or people who have been affected by forces imposed on them unilaterally and repeatedly (20). As mentioned earlier, the prevalence of LBP in children is relatively high due to several reasons. On the other hand, studies conducted among adults have shown that the first occurrence of LBP during childhood and adolescence is one of the causes of LBP in adulthood.

Moreover, no previous study was found to investigate the changes caused by LBP on the size and dimensions of abdominal muscles in children and adolescents. However, there are similar studies in this field about the size of limb muscles in children with neurological disorders, which are the source of differential diagnosis between healthy children and children with neuropathy and myopathy. Therefore, it seems necessary to conduct a study to investigate the symmetry of abdominal muscle size in adolescents with chronic nonspecific LBP. Accordingly, the present study was conducted to investigate the symmetry of abdominal muscle size between the dominant and non-dominant sides and between the painful and painless sides among healthy adolescents and adolescents with chronic nonspecific LBP.

Methods

This case-control study was conducted among 80 healthy male and female high school adolescents (40 males and 40 females), aged 15 to 18 years and 80 male and female high school adolescents with chronic nonspecific LBP (40 males and 40 females), aged 15 to 18 years, residing in Tehran (Capital of Iran). After receiving approval from the Medical Ethics Committee of the University of Social Welfare and Rehabilitation Sciences, samples were chosen using convenience sampling method while being matched in terms of height, weight and body mass index.

Healthy male and female high school adolescents (aged 15 to 18 years) with acceptable level of health according to health questionnaire and high school adolescents with a history of LBP at least within the last 3 months entered the study. Adolescents with a history of sacroiliac disorders, scoliosis and other structural disorders of the spine, respiratory diseases and rheumatism, neurological disease, waist fracture or dislocation, malignancies or other metabolic diseases, spondylolysis and spondylolisthesis, LBP during menstruation in females, professional sport activities and sensitivity to gel (by a pediatrician) were excluded from the study (26). Methods of data collection in this study were based on background information forms, inclusion and exclusion criteria, LEO-3000D1 sonography machine (XuZhou LEO Medical Equipment CO., Ltd) for measuring the muscles, Visual Analogue Scale for measuring the intensity of pain and Oswestry Disability Questionnaire for determining the level of functional disability.

First, the participants were provided with written information about the goals and methods of the study and a written informed consent was obtained from the students and at least one of the parents. They also completed the background information questionnaire. Then, participants lay down on examination table for assessment. A researcher with 5 years' experience with sonography machines captured images from the size of the abdominal muscles (transverse abdominus, internal oblique and external oblique) and the size of intra-abdominal fat using portable sonography with 7.5 MHz linear probe. The participant was requested to lie supine and the knees bent.

Then, the linear sonography probe, stained to ultrasound gel, was placed between the twelfth rib and iliac crest on the anterior (front) abdominal wall. In this posture, the size of transverse muscle, internal oblique, external oblique and the size of intra-abdominal fat at the end of exhalation (29) were measured and recorded. The data were recorded in SPSS software and were analyzed using paired t-test, while p<0.05 was considered significant.

Results

Mean age of healthy adolescents and adolescents with LBP was 16.5±1.12 (table 1).

Comparison of variables between the dominant and non-dominant sides in both groups of healthy adolescents and adolescents with LBP: The mean difference in internal oblique between the two groups was 0.861±0.21 (p=0.000) (table 2). Moreover, the difference between the dominant and non-dominant sides was significant in 49 patients with LBP on transverse abdominal muscle size (p<0.001) (table 3). Results of assessing adolescents with LBP showed a statistically significant difference in transverse abdominal muscle size and internal oblique between the dominant and non-dominant sides and muscle size was bigger in non-dominant side (1.69±0.88 vs. 2.78±0.511) (p<0.05). However, the difference in the external oblique muscle size and intra-abdominal fat between the dominant and non-dominant sides was not significant. No statistically significant difference was observed in terms of external oblique muscle size and intra-abdominal fat between the dominant and non-dominant sides in healthy participants (table 4).

Comparison of variables between painful and painless sides: Results of comparing the size of muscles and intra-abdominal fat between painful and painless sides in 31 patients with unilateral lumbar pain showed a significant difference in transverse abdominal muscles, internal oblique, external oblique and intra-abdominal fat (table 4).

According to the results, there was a significant difference in the size of abdominal muscles between painful and painless sides in patients who reported unilateral pain in their lumbar region and the size of muscle was smaller in the painful side (p<0.05).

Table 1. Demographic characteristics of participants

Underlying variables	Range	Mean±SD	Health status	P-value
Male				
Age (year)	15 - 18	16.5 ± 1.12	Healthy	0.95
	15 - 18	16.5 ± 1.12	Patient	
Weight (Kg)	45 - 98	69.4 ± 9.81	Healthy	0.89
	54 - 89	68.52 ± 8.39	Patient	
Height (Cm)	140 - 179	173.98 ± 7.71	Healthy	0.73
	160 - 181	171.5 ± 6.66	Patient	
Body mass index (Kg/m^2)	15.27 – 29.79	22.95 ± 3.10	Healthy	0.68
	20.28 – 27.15	23.24 ± 1.90	Patient	
Female				
Age (year)	15 - 18	16.5 ± 1.12	Healthy	0.95
	15 -18	16.5 ± 1.12	Patient	
Weight (Kg)	37 - 90	56.05 ± 10.52	Healthy	0.43
	46 - 91	61.90 ± 11.18	Patient	
Height (Cm)	150 - 176	164.27 ± 6.17	Healthy	0.75
	153 - 175	165.12 ± 5.35	Patient	
Body mass index (Kg/m^2)	15.27 – 28.48	20.75 ± 3.56	Healthy	0.51
	17.31 – 28.51	22.62 ± 3.38	Patient	

Table 2. Comparison of abdominal muscle size and intra-abdominal fat in healthy high school students and students with low back pain

Muscles (mm)	Mean difference Mean±SD	t-value	P- value
Transverse abdominus	0.189±0.099	1.91	0.024
Internal oblique	0.861±0.21	4.07	0.000
External oblique	0.287±0.13	2.17	0.03
Intra-abdominal fat	0.081±0.26	0.30	0.76

Table 3. Comparison of abdominal muscle size and intra-abdominal fat between the dominant and non-dominant sides in healthy adolescents and adolescents with low back pain

Variable Group	Muscle pair (mm)	Mean muscle size (mm) Mean±SD Non-dominant	Dominant	Mean difference (mm) Mean±SD	P-value
Patient (N=49)	Transverse abdominus (dominant/non-dominant)	1.38±0.53	1.64±0.64	26.0±0.34	0.001
	Internal oblique (dominant/non-dominant)	3.49±0.90	2.44±0.94	1.05±0.48	0.04
	External oblique (dominant/non-dominant)	2.76±1.01	2.83±0.69	0.07±0.37	0.17
	Intra-abdominal fat (dominant/non-dominant)	2.72±1.16	2.74±0.94	0.02±0.29	0.37
Healthy (N=80)	Transverse abdominus (dominant/non-dominant)	2.54±0.23	2.56±0.51	0.02±0.26	0.57
	Internal oblique (dominant/non-dominant)	5.08±0.68	5.17±0.94	0.09±0.41	0.18
	External oblique (dominant/non-dominant)	3.08±0.69	3.10±0.67	0.02±0.32	0.63
	Intra-abdominal fat (dominant/non-dominant)	2.62±0.90	2.66±1.38	0.04±0.43	0.47

Table 4. Comparison of abdominal muscle size and intra-abdominal fat between the painful and painless sides in 31 patients with unilateral lumbar pain

Muscle (mm)	Painless Mean±SD	Painful Mean±SD	Mean difference Mean±SD	P- value
Transverse abdominus	2.7±0.581	1.69±0.88	1.09±0.479	0.01
Internal oblique	4.79±0.791	3.01±0.779	1.78±0.429	0.03
External oblique	2.64±0.624	1.02±0.585	1.62±0.478	0.04
Intra-abdominal fat	2.75±0.986	1.50±0.986	1.25±0.257	0.04

Discussion

The results of the present study demonstrated that there was no significant difference in muscle size between the dominant and non-dominant sides in healthy adolescents, whereas the muscles were bigger in non-dominant side of patients with LBP. Moreover, the size of muscles in painful side was smaller than painless side. Rankin et al. reported the difference in the thickness of the abdominal muscles between the two sides among healthy adult people to be 12.5 to 24%. They reported a symmetry between two sides to be perfect for all muscles. Although this difference in the thickness of the abdominal muscles seems to be high and was expected to be significant, no significant difference was observed between the two assessed sides in terms of abdominal muscle size. However, there was difference between individuals under study (24). Teyhen et al. reported the difference in abdominal muscle size between the two sides and asymmetry in healthy people to be 9.2 to 11.3% (30), which was generally in line with the results of Rankin et al. The major factors that affect muscle symmetry include physical activity and anthropometric differences such as the asymmetry of the spine (scoliosis) and pelvic imbalance due to lower extremity shortening (31, 32). Gray et al. reported more atrophy in internal oblique muscle due to the significant role of this muscle in controlling the movements in patients with LBP. They also reported the bigger size of muscle in the non-dominant side (32). One of the reasons behind thicker internal oblique in the non-dominant side is the role of this muscle in unilateral rotation and bending to sides. The internal oblique muscle in the non-dominant side plays a role in forward rotation of thorax and shoulders. Therefore, bending towards the non-dominant side is performed by the internal oblique muscle in the non-dominant side, which is often observed to be done by cricket athletes and is the cause of internal oblique muscle hypertrophy among these athletes (33).

The results of the present study regarding adolescents were also in line with the results of the above-mentioned study; muscle size in the non-dominant side was bigger than the dominant side and atrophy was observed in the non-dominant side. In the present study, the external oblique muscle size was not significantly different between the dominant and non-dominant sides; one of the reasons might be the less important role of this muscle in movement control and maintaining stability. Springer et al. reported results that were similar to the study of Rankin et al. in terms of symmetry of muscles between the two sides while considering the dominant and non-dominant sides (25). The results of the present study were in line with the two above-mentioned studies; considering the dominant and non-dominant sides, there was no difference between the two assessed sides in terms of abdominal muscle size in healthy people and it can be safely claimed that there was symmetry between the two sides.

In the previous studies, researchers indicated that factors affecting the muscle symmetry and homogeneous age range are the significant causes of similarity between two sides. Results of studies regarding symmetry of lumbar multifidus muscle size demonstrated that in healthy people, there is no significant difference between two sides in terms of muscle size. Symmetry of lumbar multifidus muscle size can be helpful for detecting people with LBP and monitoring the effects of intervention. Stokes et al. reported the difference in lumbar multifidus muscle size between the two sides in healthy people to be 7.2 to 9.6% at the level of L4/L5 (26). Teyhen et al. reported the difference in lumbar multifidus muscle size between the two sides in healthy people to be about 6% (30). Hides et al. showed that the degree of asymmetry in lumbar multifidus muscle is much higher in patients with acute LBP (about 30% more asymmetry) (15).

Similar results were reported regarding patients with LBP (lasting more than 12 weeks). Braker et al. reported difference in the cross-section of lumbar multifidus muscle between two sides in patients with LBP to be 21.7% (33). Results in the study of Hides et al. were similar to the study of Braker et al.; they demonstrated lumbar multifidus muscle atrophy and pain in patients with unilateral lumbar pain. However, the difference between the two sides was less in patients with bilateral pain or pain at the center of lumbar region (2.8 to 10.5%) (34).

In addition, Keisel et al. reported the thickness of lumbar multifidus muscle in the painful side to be less than painless side (35). Studies mention unilateral pain as one of the major causes of muscle asymmetry. The present study showed a significant difference between painful and painless sides in terms of abdominal muscle size, too. Moreover, the size of muscles in the painful side was smaller than the painless side, which was in line with the results of the previous studies regarding adults. Therefore, the present study demonstrated that there is an asymmetry in abdominal muscle size among high school adolescents with LBP between dominant and non-dominant sides and between painful and painless sides.

Further studies among younger students at lower levels of education with bigger sample size as well as studies aimed at assessment of other lumbar stabilizer muscles such as multifidus in children and adolescents are suggested.

Acknowledgments

Hereby, we express our deepest gratitude and indebtedness to the University of Social Welfare and Rehabilitation Sciences for their financial support and special thanks to The Education and Training Organization of Tehran Province, Education Offices of Regions and all schools, teachers, students and their parents for their contribution.

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[DOR: 20.1001.1.15614107.1395.18.11.3.7]

[DOI: 10.22088/jbums.18.11.22]