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Altered Ultrasonographic Activity of Abdominal Muscles during Breathing in Males with and without Nonspecific Chronic Low Back Pain

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DECLARATIONS

Ethical Approval and Consent to participate

All research processes and methods were approved in terms of ethical considerations in the Research Ethics Committee of the University of Social Welfare and Rehabilitation Sciences coded.

Consent for publication

Not applicable.

Availability of supporting data

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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The authors received no financial support for the research.

Authors' contribution

AMA, RS and OR had contributions in the development of original idea, protocol development, data analysis, data collection, prepared the manuscript, and read and approved the final manuscript, also, RS drafted the manuscript.

Conflict of interest

None to declare

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Consent to participate: All participants fulfilled the informed consent form

Consent for publication: All rights will be transfered to the journal, in the case of acceptance.

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ABSTRACT

Purpose: This study aimed to investigate the altered ultrasonographic activity of abdominal muscles during breathing in males with and without NSCLBP.

Design: cross-sectional study

Methods: Twenty males with NSCLBP and 20 males without NSCLBP were recruited. Muscle thickness change was measured by ultrasonography during breathing in end-inspiration and end-expiration phases for Transverse Abdominis (TrA), Internal Oblique (IO), External Oblique (EO), and Rectus Abdominis (RA) muscles. The data were normalized to the end-inspiration thickness. The independent t-test was run to analyze data at a confidence level of 95% ($p<0.05$).

Results: The participants with NSCLBP had thicker IO muscle in the end-inspiration (P=0.030) and end-expiration ($p=0.017$) phases and greater RA ($p=0.006$) and smaller EO ($p=0.003$) normalized thickness changes during breathing.

Conclusion: The normalized thickness changes during breathing differed between participants with and without NSCLBP. Reduced EO and increased RA activity may predispose the spine to further injuries, therefore normalizing the breathing pattern should be considered in the management of people with NSCLBP.

Keywords: *Low Back Pain, Abdominal Muscles, Ultrasonography, Respiration*

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INTRODUCTION

Nonspecific Chronic Low Back Pain (NSCLBP) is one of the most prevalent musculoskeletal pain disorders that impose high costs on societies and health provider services all over the world [1]. Several treatment approaches are suggested for the treatment of NSCLBP, but evidence shows that there is no superiority between these methods [2]. Therefore, the multimodal intervention approach is commonly recommended for the sake of better clinical outcomes. This approach consists of several interventions including ergonomic advice, spinal manipulation, acupuncture, soft tissue manipulation, psychosocial interventions, general and specific exercises [3], and re-education of breathing pattern disorders [4].

Breathing is a vital and automatic function that our daily lives depend on. Evidence shows a relationship between breathing and spinal stability [4]. The diaphragm muscle is considered as the upper part of the muscular cylinder to stabilize the lumbar spine. The synergistic cooperation of diaphragm with multifidus, transverse abdominis (TrA), and pelvic floor muscles can regulate intra-abdominal pressure, contribute to lumbopelvic stability, and facilitate ventilation [5]. It is suggested that proper diaphragmatic breathing pattern is an essential mechanism to provide lumbopelvic stability [4, 5], and its possible disorders should be addressed in designing protocols for the treatment of NSCLBP [6, 7].

Previous studies have revealed the presence of diaphragmatic and breathing disorders in people with NSCLBP. For example, people with NSCLBP demonstrate less respiratory muscle endurance and diaphragmatic mobility [7], higher position of the diaphragm [8], decreased ventilation volumes [9], and greater diaphragm fatigability [10]. There is little doubt that people with NSCLBP perform their daily tasks with different movement patterns in comparison with healthy people [11]. Considering the fact that the diaphragm acts as a part of synergistic muscle groups

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stabilizing the lumbopelvic spine [5], it appears reasonable to associate the diaphragm disorders with the other synergistic muscles. In this regards, several studies have shown that people with NSCLBP have smaller thickness changes in TrA while performing abdominal hollowing-in [12], atrophy in TrA [13], absent automatic postural contraction of the TrA [14], greater thickness changes in Rectus Abdominis (RA), and lower thickness changes in TrA during unstable sitting position [15].

Even though several studies have been conducted to investigate the possible changes in the diaphragm and abdominal muscles' activation in people with NSCLBP [7-15], not many have focused on the assessment of abdominal muscles' thickness changes during breathing movement. Considering the essential role of breathing in providing proper spinal stability in the lumbopelvic region [4, 5], this study aimed to investigate the altered ultrasonographic activity of abdominal muscles during breathing in males with and without NSCLBP.

MATERIALS AND METHODS

Subjects

In this cross-sectional study, 20 males with NSCLBP and 20 males without NSCLBP were recruited voluntarily from patients who referred to public physiotherapy centers in + city name **********, from September 2019 to January 2020. During the familiarization session, prior to the study, all participants received written and verbal information about the study methods as well as the aims. They were asked to fill out informed consent forms, and their demographic data were collected using a researcher-made questionnaire. The participants were assured that their data would be confidential, and they could leave the study at any time they wanted. The referral time to the sonography laboratory was set up for each participant, too. Participants with NSCLBP within

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the age range of 20-40, with a history of LBP for at least 3 months, local pain from T12 to gluteal fold, and pain intensity less than five on the Visual Analogue Scale (VAS) were included in the study. Other participants included those without NSCLBP with no history of LBP lasting more than 1 week and within the age range of 20-40 years old. The exclusion criteria for both groups were as follows: The history of surgery in the lumbosacral region, presence of red flags [3], history of any fracture or dislocations in the lumbosacral region, presence of obvious spinal scoliosis or other spinal deformities based on New-York posture rating chart [16], history of respiratory diseases, and history of digestive diseases. The participants were recruited to the study by an expert physiotherapist who had a 10-year history of practice in the musculoskeletal field. This physiotherapist was not involved in the laboratory assessment of the study participants. The methodological and ethical considerations were approved by the Committee for Ethics in Biomedical Research of the University of Social Welfare and Rehabilitation Sciences.

1.1. Data collection

In the laboratory, all data collection was made by an experienced and qualified examiner who was blinded to the medical conditions of each subject. Also, the participants were asked not to talk about their medical condition with the examiner. Muscle thickness was evaluated using B-Mode 7.5 MHz linear array transducer (Ultrasonix-E500, made in Canada). The reliability and validity of ultrasonographic measures in the musculoskeletal assessment were approved in previous studies [17]. Muscle thickness was measured in two-phase breathing, the end of inspiration, and the end of expiration for RA, TrA, Internal Oblique (IO), and External Oblique (EO) muscles in the dominant side (the dominant hand for writing) (Figure 1). Random order was used to assess the respiratory phases. To examine muscle thickness, the participants were asked to stay in a supine crock-lying position with a pillow under both legs in a more comfortable position. Then, the

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assessment location of selected muscles was determined as below and identified with a marker. The assessment point of TrA, IO, and EO muscles was 2.5 cm in front of the midaxillary line, at the midpoint of the line, which connects the iliac crest to the last rib. For examining the RA muscle, 2.5 cm above the umbilicus, and 2.5 cm lateral to the dominant side was marked [15, 18]. Before assessing muscle thickness, ultrasound gel was placed between the transducer and the skin. The transducer was placed perpendicular to the skin with minimal pressure. To evaluate the muscle thickness at the end of expiration/inspiration, the participants were asked to exhale/inhale normally and then to hold their breath until the examiner measure muscle thickness. Each position was examined three times, and the mean average of measures was used for data analysis. The recorded image was frozen, and the muscle thickness was measured as a perpendicular distance between the inside edge of the bilateral muscle epimysium in millimeters (mm). All measurements were done with the same ultrasonography machine in the biomechanics laboratory of the University of Social Welfare and Rehabilitation Sciences. Thickness change was calculated by subtracting muscle thickness at the end-inspiration phase from the end-expiration phase., The data were normalized by dividing the measured thickness change by the end-inspiration thickness multiplied by 100 to eliminate the possible effects of individual differences.

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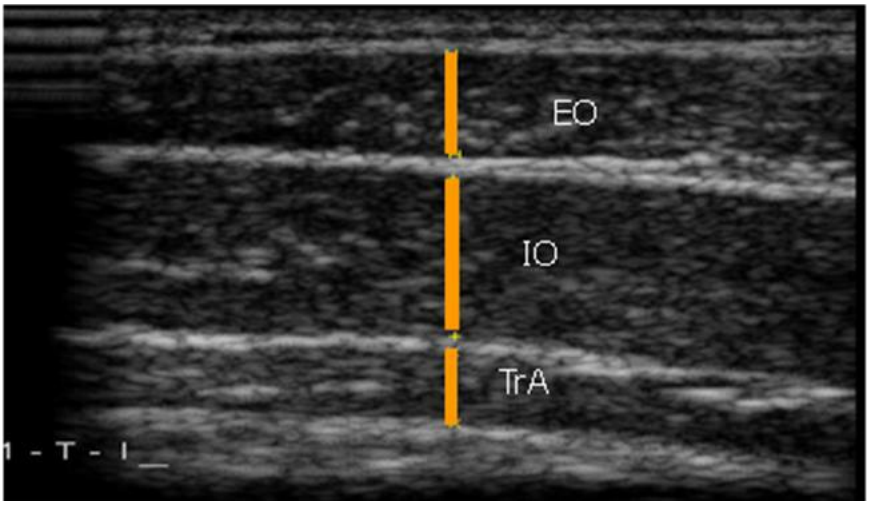
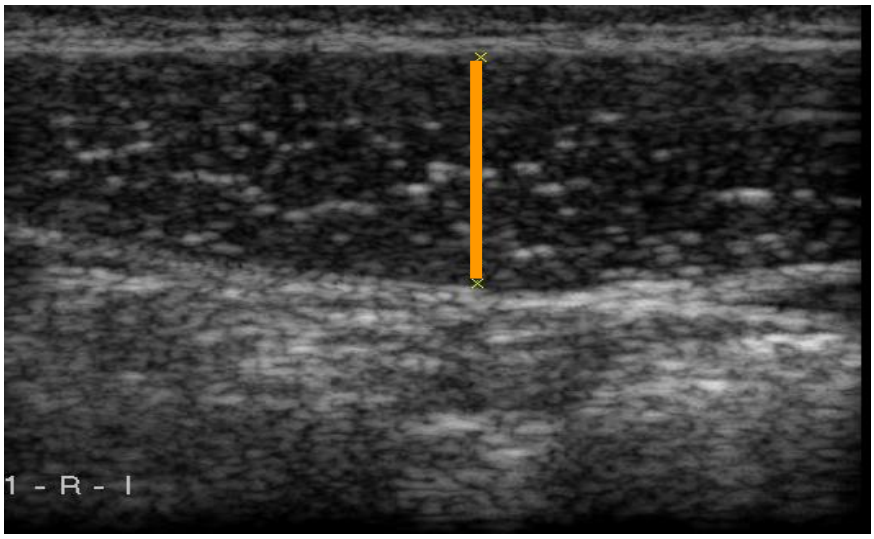


A)



B)

Figure1. Ultrasound measurement of the abdominal muscles at end-inspiration phase. A) TrA: Transverse abdominis, IO: Internal oblique, EO: External oblique; B) RA: Rectus abdominis.

Statistical analyses

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The data were analyzed using SPSS statistical package version 21. Shapiro-Wilk test was run to examine the normality of data distribution. Independent t-test was used to compare average data between two groups. Statistical confidence level was considered at 95% level ($\alpha<0.05$).

RESULTS

Both groups had no statistically significant differences in terms of age, weight, height, and BMI. The demographic data of all participants in both groups are summarized in Table 1.

Table 1: Baseline characteristics of participants with (N=20) and without (N=20) nonspecific chronic low back pain

Group	**Age (years)**	**Weight (kg)**	**Height (cm)**	**BMI (kg/m^2)**
With NSCLBP	26.40±3.57	73.55±5.61	173.85±4.96	24.30±0.91
Without NSCLBP	26.65±3.72	74.20±5.95	174.20±5.28	24.41±0.65
***p*-value**	0.830	0.724	0.830	0.670

kg: kilograms, cm: centimeters, m: meter, NSCLBP: nonspecific chronic low back pain

Comparing the data in the end-inspiration and end-expiration phase showed that the mean thickness of the IO muscle was significantly larger in the participants with NSCLBP. There were no statistically significant differences between both groups in terms of other muscle thicknesses (Table 2).

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Table 2: Comparison of the end-inspiration and end-expiration thickness of abdominal muscles in participants with (N=20) and without (N=20) nonspecific chronic low back pain

Time	Group	IO (mm)	EO (mm)	RA (mm)	TrA (mm)
End Inspiration	**With NSCLBP**	8.97±1.67	5.88±1.12	12.68±1.60	3.64±0.66
	Without NSCLBP	7.89±1.32	5.50±1.24	13.91±3.09	3.43±0.85
	P-value	0.030*	0.319	0.126	0.380
End Expiration	**With NSCLBP**	9.53±1.35	6.16±1.07	13.32±1.63	3.91±0.66
	Without NSCLBP	8.35±1.63	6.04±1.22	14.32±2.96	3.75±0.85
	***p*-value**	0.017*	0.748	0.198	0.530

IO: internal oblique, EO: external oblique, RA: rectus Abdominis, TrA: transverse abdominis, mm: millimeters, NSCLBP: nonspecific chronic low back pain, *: statistically significant difference

The results showed that there were statistically significant differences between normalized thickness changes in the RA and EO muscles, but there were no significant differences between IO and TrA (Table 3).

Table 3. Comparison of normalized thickness changes of abdominal muscles in participants with (N=20) and without (N=20) nonspecific chronic low back pain

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Group	**IO (%)**	**EO (%)**	**RA (%)**	**TrA (%)**
With NSCLBP	6.35±3.22	5.23±4.20	5.11±1.75	7.68±7.25
Without NSCLBP	6.25±3.66	10.61±6.40	3.29±2.22	10.04±4.28
***p*-value**	0.928	0.003*	0.006*	0.218

IO: internal oblique, EO: external oblique, RA: rectus Abdominis, TrA: transverse abdominis, NSCLBP: nonspecific chronic low back pain, *: statistically significant difference

DISCUSSION

The results demonstrated that the participants with NSCLBP had different ultrasonographic muscle activity compared to those without NSCLBP. The study showed that the participants with NSCLBP had thicker IO muscle in the end-inspiration and end-expiration phase and greater RA and smaller EO normalized thickness changes during breathing.

Thicker IO muscle in the end-inspiration and end-expiration phase may confirm the idea that participants with or without NSCLBP have a different muscular thickness in the lumbosacral region. In the same line, several studies have proved that participants with NSCLBP have different muscle sizes [19-21]. The current results are in contrast with a study that associated smaller IO, EO, and TrA with NSCLBP [22]. One explanation for this contrast may be different baseline characteristics of participants and the presentation of non-normalized data. A correlation has been found to exist between the muscle thickness and anthropometric data, so muscle thickness data are recommended to be normalized in future studies [23]. Accordingly, normalized thickness changes were analyzed in this study to address this issue.

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Furthermore, the results showed that participants with NSCLBP had greater RA, and smaller EO normalized thickness changes during breathing. To the best of our knowledge, no study has investigated the abdominal muscle thickness change during breathing. Our findings are in line with those who found that the thickness changes of abdominal muscles are different in participants with NSCLBP during tasks with standing posture [24], sitting with different stability levels [25], trunk extension [26], changing position [27], and sitting on an unstable surface [15].

Respiration is a vital function, which also has a crucial role in postural control and controlling the spine [28]. Patients with NSCLBP have shown a different pattern of breathing and postural controls [7-15]. It can be explained that altered breathing patterns may have an essential role in postural control deficits in people with NSCLBP [29]. Therefore, breathing exercises are recommended for the treatment of these patients [30, 31].

Previous studies have demonstrated that participants with NSCLBP have a diaphragm with a superior position [8], more fatigability [10], less mobility [7], and reduced ventilation volumes [10]. Besides, as a matter of fact, this compensatory mechanism is performed due to the vital importance of human respiration. One explanation for more ultrasonic activity of RA may be lesser mobility of the abdominal viscera of the diaphragm [7]. In this case, the activity of RA may increase intraabdominal pressure and push the diaphragm cephalad for better expiration. This compensatory mechanism may apply more compressive loads on the spine and predispose the vertebral discs into further injuries [32]. Also, the smaller ultrasonographic activity of EO may predispose the spine to more probability of spinal instability because the EO plays a stabilizer role in the spine [33]. Thus, hence the importance of the consideration of respiratory patterns in the treatment of NSCLBP.

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This study demonstrated that breathing patterns are changed in patients with CLBP. In this regard, and in line with the kinesio-pathological model of developing musculoskeletal disorders, the presence of altered breathing patterns in people with CLBP [4] may place a repetitive abnormal loading on the spine and may predispose them to further spinal or muscular damages [32]. So this study proved more evidence to support prescribing lumbosacral motor control exercises in the treatment of patients with CLBP.

One limitation of this study is that it was performed on 20-40-year old males, so the findings may not be generalized to females or adolescents with LBP. The study was conducted on participants with NSCLBP, so muscle activity changes in specific LBP like LBP associated with radiculopathies remained unclear. This study was cross-sectional, so the cause-effect relationship could not be interpreted. Furthermore, the present study examined the muscle thickness only in the right body side, and as a result, ignoring the possibility of different results that could be obtained from the left-side muscles.

CONCLUSION

The current study indicates that normalized thickness changes during breathing are different between participants with or without NSCLBP. Moreover, reduced EO and increased RA thickness changes may predispose the sine to further injuries. Thus, normalizing the breathing pattern is recommended to be considered in the management of people with NSCLBP.

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