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Examining the Effect of Adding Breathing Exercises and Pain Neuroscience Education to Home-Based Routine Exercises in Patients with Chronic Non-Specific Low Back Pain: A Randomized Clinical Trial

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ABSTRACT:
Introduction: To examine the effect of adding breathing exercises and pain neuroscience education to home-based routine exercises on pain intensity, disability, and muscular endurance in patients with chronic non-specific low back pain.
Materials and Methods: 37 participants (mean age: 10.60 ± 37 years, height: 8.87 ± 170 cm, and weight: 10.55 ± 73 kg) with chronic non-specific low back pain were randomly divided into control (n=18) and experimental (n=19) groups. Pain (Visual Analog Scale), disability (Roland Morris Questionnaire), and muscular endurance (McGill test) were assessed before and after the intervention in the experimental group. Patients in both groups performed 8 weeks of home exercises. The experimental group also performed breathing exercises and received 3 sessions of pain neuroscience education in addition to home exercises. Multivariate analysis of covariance was used to analyze the results.
Results: The results of analysis of covariance showed that adding pain neuroscience education and breathing exercises to home exercises compared to home exercises alone significantly improved pain (p=0.001), disability (p=0.001), and muscular endurance (p=0.001) variables.
Discussion and Conclusion: Combining pain neuroscience education with breathing exercises can have positive effects on pain, disability, and muscular endurance in patients with chronic non-specific low back pain. Therefore, it is recommended to use this intervention as a complementary therapeutic approach in individuals with chronic non-specific low back pain.

Keywords: Chronic non-specific low back pain, Breathing exercises, Disability, Pain neuroscience education, Muscular endurance

INTRODUCTION:

Low back pain is one of the most common musculoskeletal disorders, affecting approximately 50 to 80% of the population (1). This condition is classified based on pain duration into acute (less than 3 months) and chronic (more than 3 months), and based on risk factors into specific and non-specific types. Non-specific low back pain refers to a type of low back pain where the precise pathoanatomical diagnosis is unclear (2). Chronic non-specific low back pain is not a unidimensional condition, and in addition to physical characteristics, psychological factors are also involved. Therefore, treatment strategies for improving chronic non-specific low back pain include education and the use of non-surgical and non-pharmacological interventions such as exercise therapy (2).

One of the common factors in the development of low back pain that can be helpful in its diagnosis and treatment is the presence of instability in the core region of the trunk and spine, as well as impaired motor control in the lumbar spine region (3). Numerous studies have shown a significant relationship between weakness in core stability and low back pain, with a notable decrease in core muscle activity and spinal stabilization in patients suffering from acute and chronic conditions (4-6). This relationship has also led to studies examining differences in breathing patterns between patients with and without low back pain (7,8). Studies have reported altered breathing patterns in patients with chronic non-specific low back pain, including differences in lung capacity and diaphragm mechanics (8,9). These

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findings suggest a potential relationship between respiratory function, breathing patterns, core stability, and ultimately the onset of low back pain (8,9).

Traditional approaches for the non-surgical treatment of chronic non-specific low back pain have focused on exercise therapy and manual therapy interventions, with limited evidence suggesting that this approach has a modest effect in reducing pain and improving function (10). However, considering the role of respiratory muscles, including the diaphragm, transverse abdominis, oblique abdominis, and pelvic floor muscles, in spinal and core stability in patients with low back pain, it seems that complementary or alternative therapies such as breathing exercises may provide a suitable approach for the treatment of chronic non-specific low back pain (5). Mehling et al. (2005) investigated the effect of breathing exercises on pain and quality of life in patients with low back pain, and the results showed a significant effect of breathing exercises in these patients (11). The researchers also stated that breathing exercises not only can be a safe treatment for patients with low back pain but can also improve coping skills in these patients (11).

As mentioned, low back pain is accompanied by not only physical characteristics but also psychological disorders, which can include fear of movement, stress, anxiety, depression, and lack of self-confidence (12). Therefore, treatment methods based on education to improve psychological disorders caused by low back pain have been of interest to researchers (13). In this regard, pain neuroscience education has gained popularity and is used in patients with chronic low back pain (14). Pain neuroscience education is a type of cognitive-behavioral therapy that is often added to exercise interventions (15,16). In pain neuroscience education, patients are taught about the physiology of pain, pain-related changes in the body, representation of different body parts in the brain, and the psychosocial dimensions of pain (17). The main goal of pain education is to change the patient's misconceptions about pain (18). Pain neuroscience education provides patients with neurobiological information, making them aware that pain is not always associated with injury and can be caused by central nervous system sensitization (18). Given the effectiveness of pain neuroscience education, this intervention has been combined and compared with various other interventions. For example, Moseley reported that the combination of pain neuroscience education and movement therapy can have suitable clinical effects (19). Additionally, Nijs et al. reported positive effects from combining motor control exercises with pain neuroscience education (20). These studies have shown that combining pain neuroscience education with exercise interventions can have a significant impact on the treatment of chronic low back pain.

Therefore, considering the mentioned points, the aim of this study was to examine the effect of adding breathing exercises and pain neuroscience education to home-based routine exercises on pain intensity, disability, and muscular endurance in patients with chronic non-specific low back pain.

MATERIALS AND METHODS

This study was a retrospective randomized clinical trial registered in the Iranian Clinical Trial Registry with the code IRCT1400.1052.IR.SSRI.REC. Before enrollment, all eligible patients were asked to sign an informed consent form based on ethical standards.

Forty male and female patients aged 60.10 ± 10 years, weighing 73.55 ± 10 kg, and with a height of 170.87 ± 8 cm, diagnosed with chronic non-specific low back pain by a specialist physician and meeting the inclusion criteria, were divided into two groups: experimental (home exercises + breathing exercises + pain neuroscience education, n=20) and control (home exercises only, n=20). Sample size calculation using G*Power software with an alpha of 5%, beta of 20%, and medium effect size with a 10% dropout rate resulted in a total of 40 participants.

Inclusion criteria were: male and female aged 20 to 50 years, presence of chronic non-specific low back pain for more than 3 months confirmed by a specialist physician, no use of medications or therapeutic interventions during the study, ability to perform exercises without assistance, and ability to establish online communication. Exclusion criteria were: history of spinal or lower limb surgery, presence of inflammatory or systemic diseases, presence of spinal or lower limb fractures, presence of musculoskeletal abnormalities such as scoliosis, lordosis, or kyphosis in the spinal region, and unwillingness to participate in the study.

The experimental group's program included pain neuroscience education (3 online sessions), followed by 24 sessions of breathing exercises and home exercises over 8 weeks, while the control group only performed home exercises. One week before starting the exercises, patients were evaluated by an experienced examiner and underwent a pre-test. One week after completing the interventions, post-test data were collected by the examiner. The primary outcome was pain intensity, measured using the Visual Analog Scale. Secondary outcomes were disability and muscular endurance, assessed using the Roland Morris Disability Questionnaire and McGill tests, respectively.

Assessed Variables

The Visual Analog Scale (VAS) was used to measure pain intensity. This scale consists of a 10 cm horizontal line. The measurement process was as follows: the ruler was shown to the patient and they were asked to select the level of low back pain intensity between 0 (no pain) and 10 (unbearable pain). The selected number was recorded as the patient's pain intensity score. The VAS is a highly valid scale used in numerous studies and has appropriate validity and reliability.

The Persian version of the Roland Morris Disability Questionnaire, which has suitable validity and reliability, was used to measure disability. This questionnaire has 24 statements describing potential activity limitations. The patient is asked to check each statement that describes their current activity limitation. The number of checked statements is summed, and one point is given for each check. Scores range from 0, indicating no disability, to 24, indicating severe disability.

The McGill endurance tests were used to assess trunk muscle endurance. This test consists of 4 subtests. It has high validity and reliability. The patient is asked, after being instructed on the test, to assume the requested position, and the time the patient can maintain the test position is recorded as their score. The McGill endurance test subtests are as follows:

Flexor endurance test: The patient is asked to lie supine on a table with the knees flexed at 90 degrees to maintain a constant trunk angle for all patients. With the arms at the sides, the patient is asked to place their hands on the floor. A book is placed vertically 12 cm from the fingertips, and the patient is asked to lift their back off the table and reach the book with their fingers. The time the patient can maintain this position is measured with a stopwatch and recorded as their score.

Extensor endurance test: The patient lies prone on a table with the trunk extending off the table until the greater trochanter touches the table edge. The patient's legs are secured to the table with a strap. With the arms crossed on the chest, the patient is asked to maintain the trunk parallel to the floor. The time the patient can maintain this position is recorded as their score.

Lateral flexor endurance test: For this test, the patient is asked to assume a side plank position. The time the patient can maintain this position is recorded as their score.

Research Interventions

Home exercises were provided to both the experimental and control groups. These exercises were selected based on the study by Kanase et al. (2018) and given to the patients. Patients in both groups performed home exercises for 8 weeks. Each session included 10 minutes of aerobic activity (walking or stationary cycling), followed by 5 stretching exercises and 5 exercises to strengthen the lumbar stabilizing muscles, and finally, 5 minutes of cool-down. Stretching exercises were performed in 3 sets of 30 seconds each. Strengthening exercises consisted of 3 sets of 15 repetitions. Stretching exercises aimed to increase the flexibility of the hamstring, gluteal, and lumbar extensor muscles, as well as the anterior thigh muscles, including the quadriceps. On the other hand, strengthening exercises targeted the core stabilizing muscles, such as the plank, side plank, and curl-up, as well as the lumbar and hip muscles.

Breathing exercises were provided to the experimental group. The Kendall et al. (2010) protocol was used for breathing exercises, where the patient lies supine with the knees and hips flexed, feet on the floor. A ball is placed between the knees, the right hand is raised overhead, and the left hand holds a balloon. During the exercise, the pelvis rotates so that the coccyx lifts off the floor while the lumbar spine remains in contact with the table. The patient presses down with the heels to engage the inner thigh muscles and compress the ball between the knees. While maintaining this position, the patient inhales through the nose and slowly exhales into the balloon. The patient performs this exercise in 4 to 5 sets per training session.

Pain neuroscience education was provided to the experimental group along with home exercises and breathing exercises. In pain neuroscience education, the patient is given information about the physiology of pain, pain-related changes in the body, and the psychological aspects of pain through verbal instruction and diagrams. During the intervention, each participant in the experimental group received 3 pain neuroscience education sessions. The participants were educated by a specialist trained in pain neuroscience. The pain neuroscience education sessions lasted between 30 and 60 minutes. The goal of this education is to correct and change the patient's misconceptions about pain, such as beliefs arising from misdiagnosis or chronicity of pain. The education was conducted according to the protocol by Deliens et al. (2014).

Data Analysis

The Shapiro-Wilk test was used to assess the normality of the data. The dependent variables were analyzed using a 2 × 2 ANOVA (intervention × time) with a mixed model analysis to examine within- and between-group differences. For each variable, the percentage of change was calculated using partial eta squared. Small (0.01), medium (0.06), and large (0.14) percentages of change were calculated based on Cohen's (1992) study. All data analyses were performed using SPSS version 26 software at an alpha level of 0.05.

RESULTS

A total of 40 patients with chronic non-specific low back pain were selected. Of these, 3 patients (1 from the experimental group and 2 from the control group) did not complete the study due to personal reasons. Figure 1 shows the flow of participants through the study. Table 1 presents the demographic characteristics of the research participants, including gender, age, height, weight, and body mass index. The results did not show any significant differences between the measurement parameters.

Table 1. Demographic characteristics of the participants

Variable	Control group (18)	Experimental group (19)	Significance level
Gender			
Male	8	9	-
Female	10	10	-

Age (year)	39±11.26	36±10.10	0.444
Height (cm)	170±8.40	170±9.49	0.786
Weight (kg)	72±9.00	74±12.40	0.561
Body mass index (kg/m^2)	24±2.22	27±3.27	0.117

Table 2 shows the changes in mean and standard deviation, as well as the results of analysis of covariance regarding the measured variables in the experimental and control groups in the pre-test and post-test. According to the results obtained and the analysis of covariance, pain and disability in the experimental group showed better results after 8 weeks of home exercises, breathing exercises, and pain neuroscience education compared to the control group. This means that in the experimental group, pain (P=0.001) and disability (P=0.001) significantly decreased compared to the control group.

Regarding the variables related to muscular endurance, the results of the analysis of covariance showed that in all 4 tests of right and left lateral endurance, and extensor and flexor endurance of the trunk, the experimental group showed better results compared to the control group. So that the experimental group, after 8 weeks of home exercises, breathing exercises, and pain neuroscience education, had higher muscular endurance in the trunk muscles compared to the control group (P=0.001).

Table 2. Changes in mean and standard deviation of experimental and control groups in pre-test and post-test, and the results of analysis of covariance regarding the obtained results

Factor	Group	Pretest	Posttest	df	Mean square	F	P	Effect size (Eta squared)
Pain	Experimental	5.1±8.25	2.0±0.78	1	56.853	85.072	0.001	0.721
	Control	6.1±1.05	4.1±7.10					
Disability	Experimental	16.3±5.54	7.2±1.81	1	536.946	65.589	0.001	0.665
	Control	19.2±0.35	15.3±3.90					
Right lateral muscle endurance	Experimental	31.16±26.19	34.18±01.10	1	3499.4	31.121	0.001	0.509
	Control	35.15±31.68	35.16±88.67					
Left lateral muscle endurance	Experimental	32.17±82.80	34.18±91.32	1	2336.655	31.813	0.001	0.515
	Control	35.16±02.68	34.10±81.43					
Endurance of trunk extensor muscles	Experimental	24.11±71.46	27.14±26.89	1	1315.3.4	22.576	0.001	0.429
	Control	23.10±57.41	23.7±51.71					
Endurance of trunk flexor muscles	Experimental	39.20±55.50	42.22±50.09	1	3499.4	31.121	0.001	0.509
	Control	25.10±25.93	24.10±75.43					

* Significance at 0.001 level

DISCUSSION AND CONCLUSION

The aim of this study was to investigate the effect of combining pain neuroscience education and breathing exercises with home exercises on pain, disability, and muscular endurance in patients with chronic non-specific low back pain. The results of this study indicate the superiority of the combined intervention of home exercises + breathing exercises + pain neuroscience education compared to home exercises alone. Additionally, the experimental group showed a higher effect size compared to the control group, indicating the clinical effectiveness of the combined intervention in the present study.

These research findings are consistent with previous studies that have examined pain neuroscience education and reported reductions in pain and disability in patients. Zaheri et al. (2020) investigated the effects of pain neuroscience education on elderly patients and showed that this education can have positive effects on pain, disability, and quality of life in elderly patients. In another study, Aukfie et al. (2020) compared cognitive functional therapy with exercise interventions at 6 and 12 months in a prospective study. A total of 206 participants were involved, with 106 in the cognitive functional therapy group and 100 in the exercise intervention group. The results showed that cognitive therapy led to a significant reduction in disability but had little effect on pain compared to the exercise group. The conclusion of this study is consistent with the present study regarding the significant reduction in disability, but not in terms of the effect on pain, which suggests that the addition of breathing exercises led to a reduction in pain in the present study.

It appears that addressing the potential causes of low back pain and combining different treatment methods can improve the management of these patients. One of the structures that can cause low back pain but is often overlooked in the evaluation and treatment planning for these patients is the connection between the abdominal viscera and the musculoskeletal structures of the lumbopelvic region. Since the membranes surrounding the abdominal viscera are directly or indirectly connected to the spine through attachments to the thoracolumbar fascia, increased tension in these structures can lead to compensatory muscle activity patterns in the muscles surrounding the spine. This altered loading pattern on the spinal structures may cause musculoskeletal pain. On the other hand, reduced mobility in this region can act as a barrier to the downward movement of the respiratory diaphragm during inhalation, stimulating the proprioceptors in the diaphragm and leading to changes in the breathing pattern. These changes in breathing pattern can, in turn, compromise the activation patterns of the lumbopelvic stabilizing muscles. These changes can alter the loading patterns on the spine during daily activities and may be associated with low back pain. Therefore, addressing these changes and providing appropriate treatment strategies for these disorders can be effective in improving this type of low back pain. Furthermore, the results obtained in this study can be attributed to the combination of breathing exercise training and home exercises, suggesting that combining these techniques may have had a beneficial effect in reducing pain and disability in patients. Additionally, based on previous studies, pain education can replace the negative morphological changes caused by chronic pain with positive changes. Gray matter is crucial for information processing in the brain, and abnormal gray matter volume may affect neuronal function and connectivity. Studies have shown that gray matter volume decreases in patients with chronic pain. These gray matter morphological changes should be considered in a successful treatment, and it appears that the reduction in pain and disability in patients who received pain neuroscience education is due to a decrease in pain receptor activity and positive morphological changes.

The present study showed the positive effects of combining pain neuroscience education and breathing exercises on the muscular endurance of patients with chronic non-specific low back pain. Although the effect of pain neuroscience education on neck muscle endurance has been previously demonstrated, no study was found regarding the effect of pain neuroscience education on muscle endurance. This increase in endurance can be examined in terms of the effects of pain neuroscience education. As mentioned earlier, most patients with chronic low back pain have misconceptions such as "my spine will break" or "I will need a wheelchair in the future" due to their inability to understand and manage pain. Until the patient can develop a proper understanding of pain, they will not be able to overcome low back pain, and achieving success in treatment becomes difficult. It seems that educating the patient about pain and its management can greatly assist in the treatment process, and this awareness has led to better movement execution, resulting in increased muscular endurance in this region.

Additionally, the effect of breathing exercises on this increased endurance can be explained as follows: The muscles controlling the lumbar region include local muscles (deep and central muscles) and global stabilizing muscles (superficial and widespread muscles). The coordination of these two muscle groups can have a favorable effect on muscle performance. In stabilizing the vertebral column, the first level of stability is the control of subtle vertebral movements by the local muscles, which have a direct and strong connection with the diaphragm muscle. When the patient's breathing pattern is corrected, it improves the function of the local muscles and, consequently, the coordination of this muscle group with the global muscle group, ultimately increasing and improving muscular endurance in the lumbopelvic region.

It appears that the addition of pain neuroscience education to the treatment protocol for patients with chronic non-specific low back pain can have positive effects on pain, disability, and muscular endurance. The findings of this study showed that emphasizing the correction of patients' breathing patterns, along with pain neuroscience education, can be effective in improving the condition of patients with chronic non-specific low back pain.

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