The Effect of 2 Different Exercise Programs on Pain Intensity and Muscle Dimensions in Patients With Chronic Low Back Pain: A Randomized Controlled Trial

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Abstract

Objectives: The purpose of this study was to compare the effect of 2 exercise programs combined with electrotherapy on pain intensity and lumbar stabilizer muscles dimensions in patients with nonspecific chronic low back pain.

Methods: A randomized controlled clinical trial was performed with 41 patients with chronic LBP. Participants were randomly allocated into 2 groups: an experimental group (n = 20) received stabilization exercises plus electrotherapy, and a control group (n = 21) received routine exercises plus electrotherapy. Pain intensity, using a visual analog scale, and muscle dimensions of both right and left transverse abdominis and lumbar multifidus muscles, using rehabilitative ultrasonography, were assessed before and immediately after 4 weeks of intervention.

Results: Significant improvement was identified after interventions on pain intensity and muscle size measurements in both groups ($P < .01$ in all instances). The only exception was the right-side lumbar multifidus cross-sectional area of the control group, which was not statistically significant ($P = .081$). No significant differences were found between the 2 exercise groups on pain intensity and muscle dimensions ($P > .05$ in all instances).

Conclusions: The results of this study suggest that a combination of electrotherapy with either routine or stabilization exercise programs may improve pain intensity and muscle dimensions in patients with nonspecific chronic low back pain. (J Manipulative Physiol Ther 2018;41:102-110)

Key Indexing Terms: *Low Back Pain; Stabilization; Exercise; Ultrasonography; Pain Intensity; Muscle; Thickness*

Introduction

Nonspecific chronic low back pain (LBP) is among the most common musculoskeletal disorders, affecting 58% to 84% of people at least once in their lives.[1-5] It may result in pain, disability, and work absence. The annual prevalence of LBP was reported as 50% of working age adults.[3-5] The direct and indirect costs of LBP are as high as cardiovascular diseases, diabetes, depression, and headache.[4] In the United States, LBP was identified as the second most common reason for visiting a physician. Cost for treatment is estimated to be about $50 billion annually.[6] Although only a small percentage of patients with LBP develop chronic pain, this minority seems to be responsible for the huge direct and indirect costs of LBP.[6] Despite extensive investigations on the diagnosis of LBP, the exact pathology is still not clear. Among different causes of low back disorders, facet joint dysfunction, disc disorders, ligament or nerve problems, muscle weakness, and imbalance have been listed (defined as nonspecific LBP).[1] Other causes include tumors, congenital abnormalities, fractures, spinal injuries, and inflammatory and rheumatic diseases as well as sciatica (defined as specific LBP). Pain itself may lead to motor control dysfunction, which in turn can increase the pain intensity in a vicious cycle.[7,8]

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Paper submitted June 4, 2016; in revised form February 17, 2017; accepted March 21, 2017.
0161-4754

http://dx.doi.org/10.1016/j.jmpt.2017.03.011

Various treatment programs, such as rest, medications, exercise therapy, traction, osteopathic treatment, manipulation, massage, and electrotherapy (eg, diathermy, laser, musculocutaneous and nerve electrical stimulation, and interferential currents) have been suggested for patients with LBP.[9-11] Among exercise programs,[12,13] a stabilization exercise program has received more attention within the past 2 decades. This program is commonly used for its short- and long-term advantages, including pain reduction and facilitation of the neuromuscular control at lumbar spine.[14,15]

Therapeutic exercise is considered as a treatment that encourages patients to engage their muscles. It is recommended as a complementary treatment after the acute phase of LBP. van Tulder et al[16] reported a significant effect of exercise therapy on chronic LBP. Exercises, which are routinely used in physiotherapy clinics, are mainly designed to activate paraspinal and abdominal muscles. Recently, exercises that are related to the engagement of stabilizer muscles[17] such as transverse abdominis (TrA), lumbar multifidus (MF), and internal oblique (IO) have received more attention. Unlike erector spinae and rectus abdominis (which seem to be involved in movement production), these muscles provide segmental stabilization by maintaining a neutral intervertebral position during exercises and functional activities.[18]

Co-contraction of deep muscles such as TrA, lumbar MF, and IO as well as pelvic floor muscles produce a force that may contribute to the stability of the spine through thoracolumbar fascia and interabdominal pressure mechanisms.[19] Accordingly, these muscles play a supportive role for the spine. For example, lumbar MF muscle resists the force coming from outside by engagement during the full range of spine movement and also during movements of upper and lower extremities. Because these muscles are always active during all activities of daily living and exercises, they do not need much power, although good endurance and coordination are required to keep the back in normal position through their constant activities.[19,20] Some techniques, such as magnetic resonance imaging,[21,22] electromyography (EMG),[23,24] and ultrasonography (US)[25-28] are available to detect changes in muscle activities and morphologies. US seems to be superior in terms of safety, accessibility, and cost.

However, because there is no general consensus on the effect of stabilization exercise programs in patients with LBP, the purpose of the present study was to evaluate the effect of 2 types of exercise programs on pain intensity and dimensions of TrA and lumbar MF muscles using US.

It was hypothesized that there would be a significant difference between a stabilization exercise program combined with routine physiotherapy and a routine exercise program combined with routine physiotherapy on pain intensity and dimensions of TrA and lumbar MF muscles using US. The purpose of this study was to compare the effect of 2 exercise programs combined with electrotherapy on pain intensity and lumbar stabilizer muscle dimensions in patients with nonspecific chronic LBP.

Materials and Methods

Study Design

A randomized controlled trial was designed to compare the effect of stabilization versus routine exercises on pain intensity and muscle dimensions in patients with nonspecific chronic LPB. Forty-one patients with nonspecific chronic LBP, who were referred by an orthopedic surgeon, were recruited in an outpatient orthopedic clinic. Sample size was estimated[1] on the basis of the power of the study $1 - \beta = 80\%$[2]; to detect the effect size of $d = 0.5$; and[3] to produce a significance level of $\alpha < 0.05$[4]; with a 95% confidence interval, that required 21 participants for each group. The participants were included if they were between 18 and 55 years old, had good general health (using the Farsi version of the 12-item General Health Questionnaire),[29] and were suffering from a nonspecific chronic LBP (with no clear pathologic cause) that had lasted for at least 12 weeks. The exclusion criteria were any history of pain, numbness, or urinary incontinence, indicating cauda equina syndrome along with LBP, and a history of spinal surgery. Patients with severe medical conditions (eg, osteoporosis, infections, neoplasm, and inflammatory diseases), structural abnormalities (eg, scoliosis), compression fracture, and pregnancy were also excluded. This study was approved by Medical Ethics Board at the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. Participants provided their consent according to the ethical guidelines and principles of the international Declaration of Helsinki for research. The study was conducted from December 2012 to February 2014.

Patients were randomly assigned (using a block-style randomization scheme) into either an experimental group (n = 20) receiving electrotherapy and stabilization exercises or a control group (n = 21) receiving electrotherapy and routine exercises (Fig 1). A physical therapist was responsible for delivering treatments to both groups. Pain intensity was subjectively reported by participants, and muscle dimensions were measured by an experienced radiologist who was blinded to patients' allocation.

Outcome Measures

Before implementing the intervention, participants were invited to receive oral and written information about the aims and purposes of the study. The patients then completed a questionnaire including questions on demographic data such as gender, weight, height, body mass index, history of back pain, and general health condition and pain intensity was assessed on a visual analog scale.[30] This was followed by measuring muscle dimensions (right and left TrA and MF muscles) by a radiologist using US (Ultrasonic-ES 500, Canada) with 2

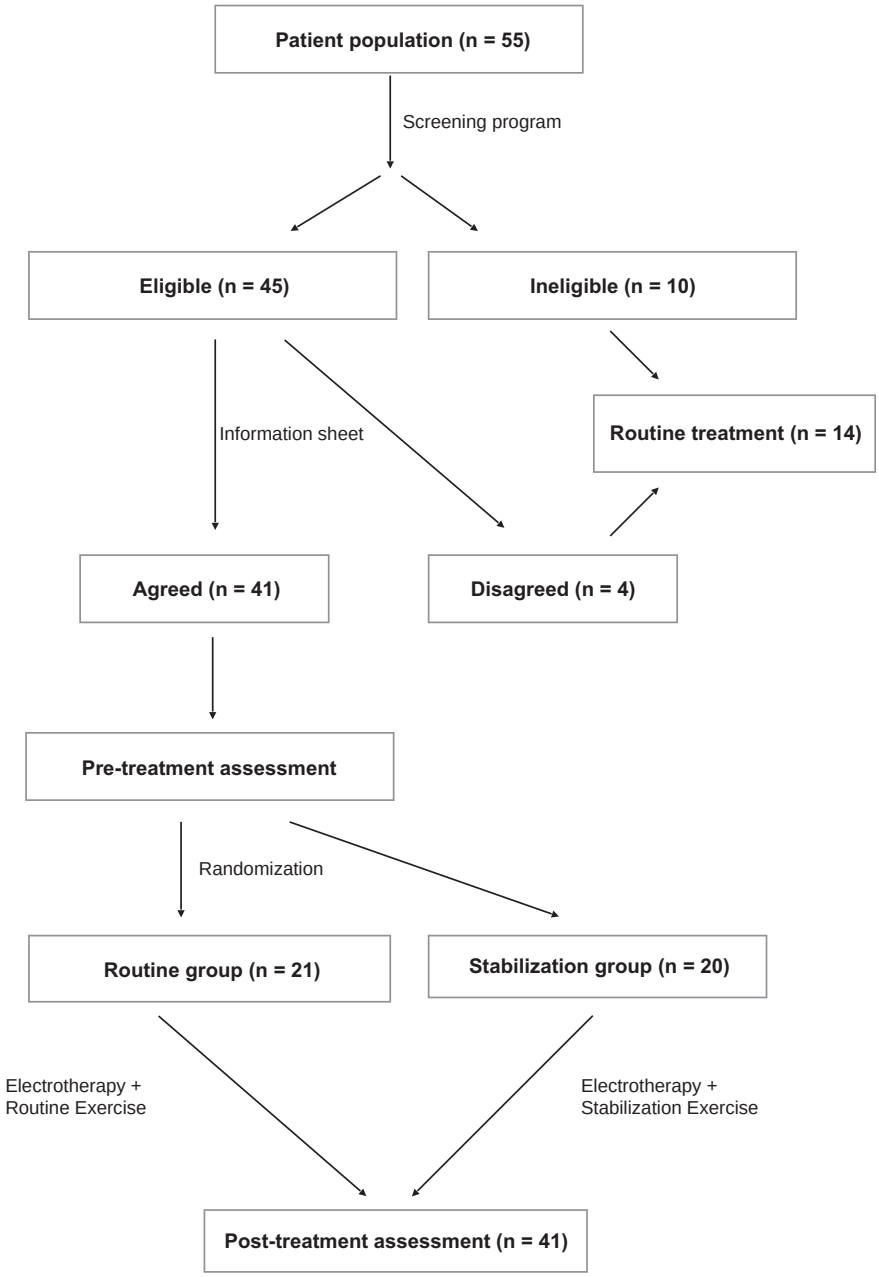

Fig 1. *Flow diagram of patient recruitment.*

probes (linear 7.5 MH_Z for TrA and curvilinear 3.5 MHz for LM). The TrA was measured in the supine hook-lying position with the hand under the head. The linear probe (7.5 MHz) was placed at the level of the axial line between the iliac crest and the 12th rib. LM was measured in the prone position (on a standard plinth to decrease the lumbar curve) and at the L5 level. All measurements were taken at the end of expiration in a relaxed state. Although the reliability and validity of US in the assessment of skeletal muscles have been reported in many studies,[26-28] the reliability of this device was primarily investigated and the results were published separately.[31] Patients were then given different interventions based on the design of the study.

Interventions

Both groups received routine physiotherapy including electrotherapy and warmup exercises. Electrotherapy is routinely prescribed by different consultants for the physiotherapy treatment of patients with LBP. Because it was not ethically possible to deprive patients of what they would normally receive, it was decided to keep the routine treatment

Fig 2. *Warmup exercises.*

for patients and add stabilization exercises in addition for the experimental group. Electrotherapy components consist of 5 minutes of therapeutic US and 15 minutes of continuous transcutaneous electrical nerve stimulation with concurrent infrared radiation.[32] Warmup exercises were the same for both groups (Fig 2). To ensure participants' learning and performance and control for bias, weekly exercises were shown through figures and instructions in a leaflet. In this process, participants were asked to perform their exercise program under the physiotherapist's supervision. Those who were not eligible or not willing to participate were given routine treatment.

The physiotherapist monitored patient status if the patient could get to the next step of the exercise program. The criterion for progression was based on the ability of patients to hold the current exercise for 10 seconds and 10 times without fatigue. If they were found eligible to move forward, new leaflets containing the new routine (Fig 3) or stabilization (Fig 4) exercise images and related instructions were given weekly. Taking into consideration the differences in individuals' exercise capacity, a 4-week exercise program was planned for each patient. Treatment sessions were managed 3 times a week, and after 4 weeks, reassessment of pain intensity and muscle dimensions was performed. Each participant was tested at the same time of the day to avoid diurnal variations. All treatment programs were implemented in the physiotherapy clinic at the department of physiotherapy of the University of Social Welfare and Rehabilitation Sciences.

Statistical Analyses

Data analysis was carried out with SPSS Version 21 (IBM Corp., Armonk, New York). The descriptive statistics (mean and standard deviation) values were calculated for each variable. Statistical significance was determined at 0.05. A paired *t* test was used to assess changes within each group after interventions. Differences between the 2 groups were also evaluated using an independent sample *t* test.

Results

Demographic characteristics of patients in each treatment group are listed in Table 1.

Baseline data analysis indicated no significant differences in demographic characteristics or in all outcome measures between the 2 groups before the treatment ($P > .05$ in all instances).

Statistical tests regarding the effect of intervention in each treatment group indicated significant improvement in pain intensity and TrA muscle dimensions in both groups ($P < .05$ in all instances). Although lumbar MF cross-sectional areas were significantly improved in the experimental group (both sides), in the control group changes were significant only on the left side (Table 2). Comparison of changes between the 2 groups revealed no significant differences between the 2 groups in terms of pain intensity and muscle dimensions (Table 2).

Discussion

The present study was designed to compare the effect of stabilization exercise vs routine exercise on pain intensity and muscle dimensions in patients with nonspecific chronic LBP.

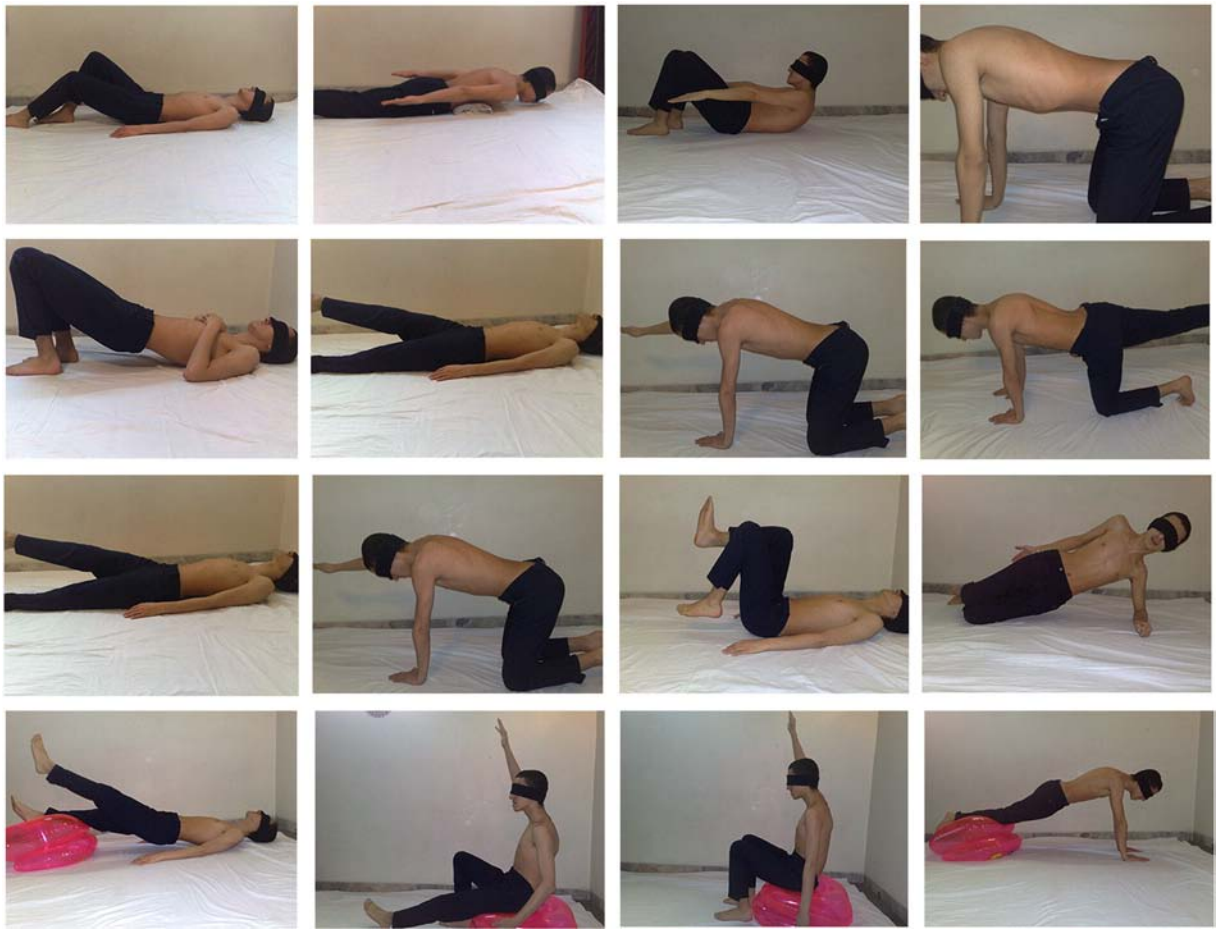

Fig 3. *Routine exercises (4 weeks).*

There is ample evidence for using stabilization exercises in the treatment of patients with nonspecific chronic LBP, but they are still surrounded by controversy.[33] It must be kept in mind that in the majority of reports, treatments were accompanied by other interventions (most commonly manual therapy). The literature supports that the combination of treatments has proven to be more effective than single stabilization exercises.[33]

Effect of Interventions on Pain Intensity

It was hypothesized that there would be significant statistical differences on pain intensity between stabilization exercises and routine exercises in patients with nonspecific chronic LBP. The results in the present study do not support this hypothesis. This finding is in agreement with the findings of a randomized controlled trial conducted by Descarreaux et al[34] and the findings of a systematic review carried out by Slade et al.[35] The results of the present study are inconsistent with those reported by Koumantakis et al,[36] who found a combination of stabilization and routine exercises were more effective on pain intensity in LBP patients. They included 55 participants with subacute and chronic LBP together, defined chronic LBP as lasting 6 weeks or more, and implemented their interventions for 8 weeks. These methodological differences among conducted studies may explain the variations in results and conclusions of previous studies and may justify further research.

Effect of Interventions on Muscles Dimensions

It was hypothesized that there would be significant statistical differences in TrA and lumbar MF thickness between the experimental group and the control group of patients with nonspecific chronic LBP. The findings of the present study do not support this hypothesis. In agreement with the results of this study, Ferriera et al[8] reported improvement in the dimensions of TrA muscle assessed by US in 2 groups of healthy and LBP patients. They also reported less improvement in muscle thickness of LBP patients, which may be attributed to the higher threshold of

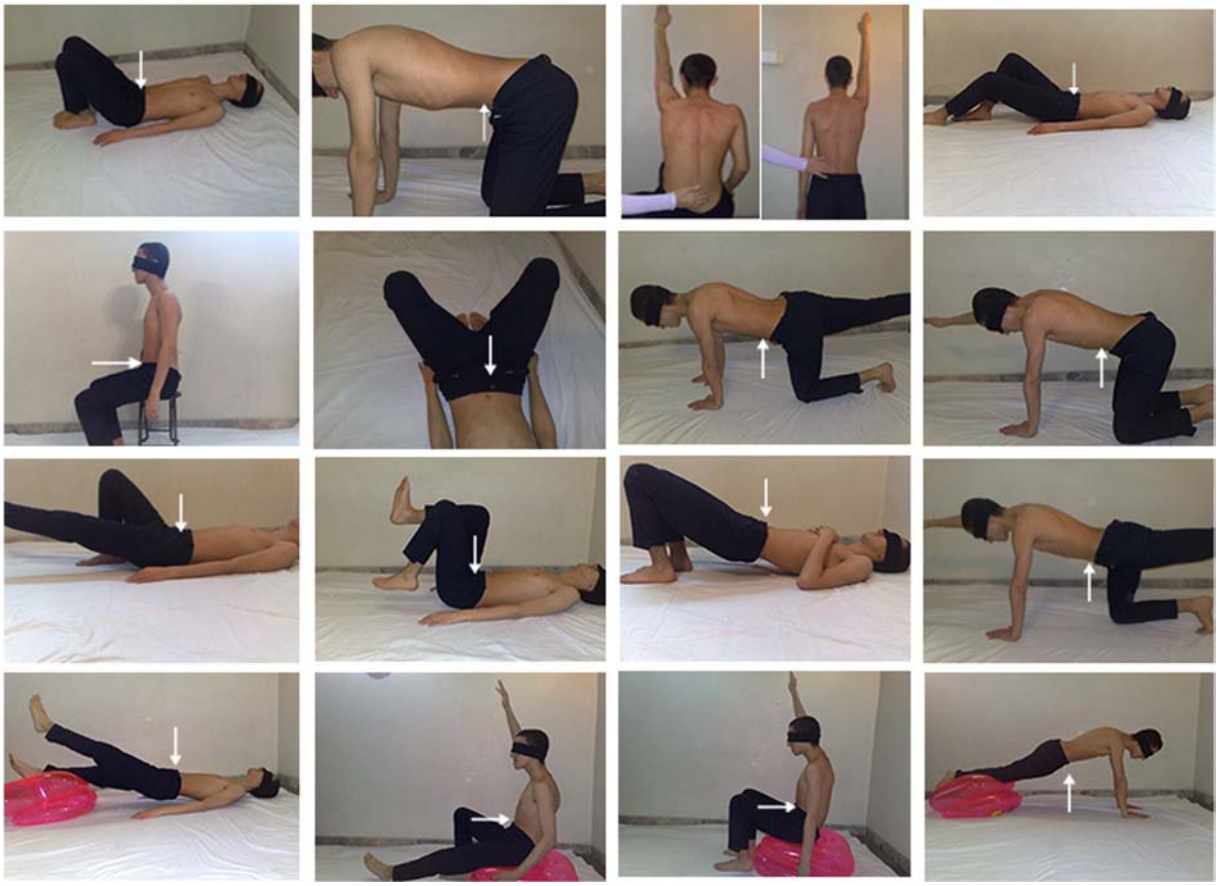

Fig 4. *Stabilization exercises (4 weeks).*

Table I. *Patients Characteristics in Both Experimental and Control Groups*

	Stabilization Group		Routine Group	
Patient Characteristics	Mean	Standard Deviation	Mean	Standard Deviation
Age (y)	40.75	8.23	34.05	10.75
Height (m)	1.68	0.08	1.65	0/08
Weight (kg)	70.15	14.53	72.05	10.77
Body mass index (kg/m^2)	24.86	4.39	26.39	3.21

muscle activation in these patients. This (the higher threshold of muscle activation in these patients) may also justify some small changes in muscle thickness found in the present study.

Stevens et al[12] studied the effect of stabilization exercises on trunk movement pattern in healthy individuals. Using both US and EMG, they found high activity by local abdominal muscles, no significant change in local muscles, and limited changes in global muscles during trunk activities, including bridging and quadruped positions.[12] These positions were used in the present study as well. Although nearly similar results were reported for both abdominal and back muscles, the differences may be attributed to the younger participants included in the Stevens et al[12] study.

Another confirmatory finding was suggested by Mannion et al.[37] They applied US measurements of TrA thickness and reported significant improvement in healthy and LBP individuals with an abdominal hollowing exercise in the hook-lying position.[37] This finding was similar to the finding of the present study in terms of the methodology and type of exercise programs. Kiesel et al[38] also reported a significant increase in MF thickness after exercise using both US and EMG.

Overall, the results indicated that both exercise programs were effective in reducing pain intensity and improvement of TrA and lumbar MF muscle dimensions in patients with nonspecific chronic LBP. The study did not support the significant preference of the stabilization exercise over routine exercise programs.

Table 2. *Mean Differences (95% Confidence Intervals) of Intra- and Intergroup Changes in Pain Intensity (cm, on Visual Analog Scale) and Muscle Size and Cross-Sectional Area (mm and mm^2) After Treatment*

	Within-Group Analysis				Between-Groups Analysis	
	Experimental Group [a]	*P*	Control Group [a]	*P*	Mean Difference and 95% Confidence Intervals	*P*
Pain intensity (cm)	3.30 (2.15-4.27)	.01	3.48 (2.18-4.12)	.01	0.18 (0.02-0.34)	.82
Right TrA (mm)	0.48 (0.22-0.59)	.01	0.37 (0.28-0.61)	.01	0.11 (–0.09 to 0.12)	.81
Left TrA (mm)	0.31 (0.19-0.58)	.02	0.37 (0.11-0.62)	.01	0.06 (–0.08 to 0.28)	.92
Right LM (mm)	1.50 (1.08-2.11)	.013	1.79 (0.98-2.22)	.01	0.29 (0.13-0.54)	.53
Left LM (mm)	1.53 (0.92-2.39)	.01	1.72 (0.81-2.45)	.01	0.19 (0.04-0.41)	.64
Right CSA of LM (mm^2)	0.36 (0.16-0.59)	.01	0.26 (0.03-0.55)	.081	0.09 (–0.06 to 0.24)	.86
Left CSA of LM (mm^2)	0.51 (0.17-0.77)	.01	0.24 (0.06-0.47)	.045	0.27 (–0.10 to 0.19)	.66

CSA, cross-sectional area; *LM,* lumbar multifidus; *TrA,* transverse abdominis.
[a] Mean changes and 95% confidence intervals

Limitations

The results of this study should be evaluated based on the following limitations. In this study, 1-hour treatment sessions 3 times per week were performed for 4 weeks. The result could have been different if patients had received a longer period of treatment. In this study, only the changes immediately after the interventions were assessed. There were no follow-up measurements to assess the long-term effects. The physiotherapist was also one of the assessors, and it was not possible to keep her blinded to the 2 patient groups.

Suggestions for Future Research

Further research is recommended to evaluate the effect of exercise in a larger number of participants, including both healthy and LBP patients, to assess the effect for long-term follow-up, to explore the association between function improvement and pain intensity, and to study the effect of exercise on unilateral or bilateral pain. Further study is also recommended to assess the effects of exercise after receiving feedback using necessary instruments (eg, US) to help patients understand and perform muscle contractions appropriately.

Clinical Implications

If further large-scale research gives support to the findings of the present study, both routine and stabilization exercises can be prescribed for the treatment of patients with nonspecific chronic LBP in physiotherapy clinics. Meanwhile, because there was no significant difference between the 2 exercise programs at 4 weeks, each of these programs can be considered useful for patients with LBP.

Conclusions

The present study determined that both routine and stabilization exercise programs, in addition to routine physiotherapy, were effective on pain intensity and TrA and LM muscle dimensions in patients with nonspecific chronic LBP. The study found no preference of the 4-week stabilization exercise program over routine exercises, although the stabilization exercises seemed to be more effective in the improvement of the lumbar MF cross-sectional area.

Funding Sources and Conflicts of Interest

The University of Social Welfare and Rehabilitation Sciences provided financial support of this study. No conflicts of interest were reported for this study.

Contributorship Information

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

Practical Applications

- Both routine and stabilization exercise programs, in addition to routine physiotherapy, were effective on pain intensity and TrA and LM muscle dimensions in patients with nonspecific chronic LBP.
- No superiority was found for the 4-week stabilization exercise programs over the routine exercise in the treatment of patients with low back pain.
- Future studies with a longer period of implementation of stabilization exercises are recommended.

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