

# The effect of motor control exercise versus general exercise on lumbar local stabilizing muscles thickness: Randomized controlled trial of patients with chronic low back pain

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**Abstract.** *Background:* The specific training of lumbar local stabilizing muscles is one of the recent focuses in management of patients with chronic LBP. Enhanced stability of the lumbar spine segments is the mechanism for pain relief with this specific exercise.

*Objective:* The aim of this study was to compare the effect of motor control exercises with general exercises on the lumbar local stabilizing muscles thickness, activity limitation and pain in patients with chronic low back pain (LBP).

*Design:* A double-blind, randomized controlled trial.

*Methods:* Forty-nine patients with chronic LBP were randomly assigned to either a motor control ( $n = 25$ ) or a general exercises group ( $n = 24$ ). Before and after intervention, we assessed the lumbar multifidus (LM) and Transversus abdominis (TA) muscles thickness (mm) using a 7.5 MHz B-mode transducer ultrasound, pain through visual analog scale and activity limitation through Back Performance Scale (Ordinal). A 16 session's exercise program which lasted 8 weeks, twice per week, and 30 minutes per session was performed for both groups.

*Results:* The mean TA thickness increased from  $1.87 \pm 0.63$  mm to  $2.39 \pm 0.63$  mm in the motor control group and from  $1.93 \pm 0.49$  mm to  $2.22 \pm 0.47$  mm in the general exercise group ( $P < 0.0001$ ). The mean LM thickness increased from  $8.63 \pm 2.37$  mm to  $9.69 \pm 2.49$  mm in the motor control group and from  $8.83 \pm 1.53$  mm to  $9.26 \pm 1.56$  mm in the general exercise group ( $P < 0.0001$ ). The mean activity limitation decreased from  $8.83 \pm 3.38$  to  $5.42 \pm 2.43$  in the motor control group and from  $10.67 \pm 2.81$  to  $7.25 \pm 2.73$  in the general exercise group ( $P < 0.0001$ ). After treatment, there was no significant difference between two groups, with the exception of pain ( $P > 0.05$ ).

*Conclusion:* The motor control and general exercises decreased pain and increased TA and LM muscles thickness and lumbar mobility in patients with chronic LBP without any signs of spinal instability. Although, the motor control exercises were more effective than general exercises in pain decreasing.

**Keywords:** Low back pain, motor control exercise, general exercise, ultrasonography, lumbar multifidus, transversus abdominis, activity limitations, randomized controlled trial

## 1. Introduction

Musculoskeletal disorders, of which back pain accounts for more than half the number of cases, are the most common cause of chronic incapacity in industrialized countries [10]. Approximately 10–20 percent of patients with low back pain (LBP) develop chronic

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pain, defined as LBP persisting more than 3 months [8]. LBP represents a particularly costly sociomedical problem [18]. These patients use more than 80% of health care resources [50]. Thus, the development of effective interventions aimed at management of the chronic problems is urgently required [30].

Chronic LBP is a multifactorial phenomenon and it is not surprising that many therapeutic approaches exist [35]. There are ample evidences that active approaches, such as exercise therapy, are beneficial for patients with sub acute and chronic LBP [1,9,15]. Positive results have been documented with different types of exercise, suggesting there are few evidences that a particular "type" of exercise is any better than another [49]. The effectiveness of classic trunk exercises, that they activates the abdominal and paraspinal muscles [3,31], were reported on the several randomized controlled trials (RCTs) [26,42]. While some trials of exercise therapy have reported clinically important effects of treatment [25,36] others have not [53]. Many factors contributed to the inconsistent results across trials. Importantly, interpretation of the results of exercise trials is difficult because most trials have been pragmatic trials. Secondly, the quality of exercises was not controlled [29]. Lastly, methodological quality varies greatly across previous exercise trials. Increasing attention recently has been paid to the preferential re-training of the local stabilizing muscles of the spine [19, 36]. Lumbar multifidus (LM), transversus abdominis (TA), and internal oblique muscles with intervertebral attachments are better suited for providing intersegmental stability, opposed to the longer trunk muscles, dedicated to generating movement [6].

No RCT has tested the assertion that stabilization training is beneficial in patients with chronic LBP using pain and disability as outcomes [27]. Morton found that stabilization training of LM was less effective than when combined with a course of manipulative therapy in nonspecific LBP [34]. Some evidences support the role of stabilization exercises in LBP with respect to symptom recurrence, but the 2 relevant RCTs have been conducted in specific subgroups of patients with LBP [19,36]. The first study [19] compared stabilization exercise against standardized medical care in acute first-episode unilateral LBP [19]. A 3-year follow-up showed a link between improvement in LM cross-sectional area (CSA) and reduced LBP recurrence in the group that received stabilization exercise [20]. The second study, comparing stabilization exercise against general exercise in patients with lumbar spondylolysis or spondylolisthesis, indicated large short-term and

long term improvement in favor of the stabilization exercise group on pain and disability [36]. However, in these 2 trials, the specific effect of the stabilization exercise was not compared to general back and abdominal exercises. A RCT on 160 patients demonstrated that either motor control or general exercises were accompanied by large improvements in pain and disability. However, motor control exercise produced significantly better outcomes in the short term and at 6 month follow up [14]. A more recent study in patients with nonspecific chronic LBP, in contrast with two previous studies, demonstrated positive results for LM muscle CSA increase in favor of general exercise [12]. This finding contradicts the theory that general exercise would not be as effective for restoration of LM size [41]. Koumantakis also showed that general exercises reduced disability in the short term to a greater extent than stabilization-enhanced exercises in these patients [27].

The effectiveness of stabilization exercises in patients with nonspecific LBP is not yet fully established. In clinical trials that reported improvement after motor control exercise, other interventions also accompanied. The results of the studies also are different. On the other hand, the primary aim of motor control exercise, which is to re-establish normal control of the deep spinal muscles, reducing the activity of more superficial muscles, and then maintain normal control during progressively more demanding physical and functional tasks [41]. For these reasons, we decided to determine the efficacy of motor control exercises, usually considered as specific trunk muscle stabilization exercises, through a RCT in chronic LBP. Our choice also coincides with the research agenda set by the 2004 European Guideline [11]. For this, before and after motor control and general exercises, we determined TA and LM thickness, activity limitation and pain. We hypothesized that the motor control exercises would increase TA and LM thickness. Activity limitation and pain would decrease following two protocols that it would be more in motor control group than general one.

## 2. Materials and methods

### 2.1. Design

This was a double-blind, randomized controlled trial with patients randomly assigned to 1 of 2 treatments group. The first group treated with the motor control exercise and the other with general exercise. The physical

therapist who administered the exercise programs could not be masked to group allocation. The radiologist who measured muscles thickness, the researcher who evaluated the pain and activity limitation and analyzed the data and participants were blinded to group assignment. A 16 individually supervised half-hour session's exercise program which lasted 8 weeks and twice per week was performed for both groups in Razmejo-Moghadam Physiotherapy Clinic, Zahedan University of Medical Sciences, Zahedan, Iran, in 2006–2007 [27]. Before and after intervention, treatment outcomes were measured in both groups. The University Ethics Committee approved the protocol of the study, and all patients gave their written voluntary informed consent before participation.

## 2.2. Participants

We recruited 63 subjects with chronic LBP from the physiotherapy clinics. We conducted a diagnostic triage to screen for serious pathology [51]. Eligible participants were screened for contraindications to exercise using the Physical Activity Readiness Questionnaire (PARQ) [2]. If a subject gave a positive response to items 1, 2, 3, 4, 6 or 7, for medical review and excluding any contraindication to exercise as listed in the ACSM guidelines referred to physician [2]. We used the clinical assessment to ensure that the applied motor control approach was based on the key text [41]. The assessment involves evaluation of the motor control strategy during a specific trunk muscle task; drawing in of the lower abdomen while maintaining an isometric contraction of the medial back muscles. Correct performance of the task is dependent on moderate and sustained activation of TA and LM for more than 10 s, little or no activation of the global trunk muscles, no spinal or rib cage movement, and normal breathing [41]. Patients who were unable to perform this task correctly would be considered suitable for motor control exercise. Patients were selected based on following inclusion criteria: nonspecific LBP with or without leg pain of at least 3 month duration aged greater than 18 and less than 80 years, suitable for motor control exercise based on clinical assessment. The patients must also have sufficient knowledge of the Persian language to understand instructions. Patients were excluded if they had suspected or confirmed serious spinal pathology, suspected or confirmed pregnancy, nerve root compromise (2 of strength, reflex or sensation affected for same nerve root), spinal surgery, and any of the contraindications to exercise listed on page 42 of the ACSM guide-

lines [2]. Specific spinal pathology or contraindication to treatment may be suspected based on the results of the screening questionnaire and the PARQ.

## 2.3. Data collection

Researcher interviewed and examined all subjects, to ensure that the inclusion and exclusion criteria were fulfilled. Subjects were questioned regarding the onset of their pain, current pain duration, and age. Weight, height and body mass index were also measured.

## 2.4. Randomization

Patients were randomized through a physical therapist generated random number sequence.

## 2.5. Outcome measures

### 2.5.1. Muscle thickness measurement

TA and LM thickness (mm) were assessed using a 7.5 MHz B-mode transducer ultrasound (Sonoline Adara; Siemens Medical System, Inc; Issaquah, WA, USA) [33] which a high resolution for muscle examination can be achieved [4]. Before starting the study we carried out preliminary session to define where to position the ultrasound probe. We looked for a position that would be easily identifiable by anatomical landmarks and allow continuous ultrasound visualization of each muscle boundary during thickening. Each muscle was identified easily thanks to separating clear bright lines representing muscle sheets. Based on previous studies [13,46], for TA, patient lay supine and we placed the probe midway between the costal margin and the iliac crest, along the right anterior auxiliary line. For LM, patient lay prone and we moved the probe around the L4 and L5 distanced 5 cm from their spinous process.

### 2.5.2. Activity limitation assessment

Activity limitation was assessed using Back Performance Scale (BPS). BPS consists of 5 tests (Sock Test, Pick-up Test, Roll-up Test, Finger tip-to-Floor Test, and Lift Test), all requires sagittal-plane mobility [45]. Discriminative validity and responsiveness to important change are known for each of the tests [44]. BPS was more responsive than the separate tests for mobility-related activities [45]. In all tests, performance is assessed using a 4-point ordinal scale. A score of 0 was considered a good performance, 1 was considered a somewhat limited performance, 2 were considered a rather distinct limitation of performance, and 3 were considered a substantially limited performance [45]. Range of BPS sum scores varies from 0 (good performance) to 15 (limited performance) [45].

Table 1  
Between-group baseline comparisons of subjects' characteristics prior to randomization

	Motor control group (n = 25)	General group (n = 24)	P value <sup>c</sup>
Anthropometry			
Age (y)	39.6 ± 3.5 <sup>b</sup>	40 ± 3.6	0.72
Height (cm)	171.2 ± 2.7	172.08 ± 2.2	0.2
Weight (kg)	73.7 ± 3.1	74.6 ± 2.4	0.26
BMI <sup>a</sup> (kg/m <sup>2</sup> )	25.2 ± 1.7	25.21 ± 1.02	0.98
History of LBP <sup>a</sup>			
Current duration (wk)	45.7 ± 1.9	44.4 ± 3.1	0.09
Time since first onset (mo)	15.08 ± 1.9	14.9 ± 1.4	0.73

<sup>a</sup>BMI = body mass index, LBP = low back pain.

<sup>b</sup>Values are Mean ± Standard Deviation.

<sup>c</sup>Statistical different at  $P < 0.05$ .

### 2.5.3. Pain measurement

The Visual Analog Scale (VAS) was used to assess each patient's pain perception. It is a responsive pain scale that yields reliable and valid data [45]. VAS rated on an intensity scale from 0 to 100 mm, with higher scores representing higher levels of pain [32].

## 2.6. Intervention

### 2.6.1. Motor control exercise

The motor control exercise program is based on the treatment approach reported by O'Sullivan et al. [36], Richardson et al. [41], and Moseley [35]. Briefly, low-load activation of the local stabilizing muscles was initially administered, isometrically and in minimally loading positions (4-point kneeling, supine lying, sitting, standing) [27]. Patients were taught how to contract these muscles independently from the superficial trunk muscles [41]. Progressively, the holding time was increased to the point where patients were able to perform 10 contractions with 10 s holds, during normal respiration (weeks 1 and 2) [27,40]. Consequently, the dynamic exercises were contributed [41]. Motor control exercises were specified for each stage [27]. The clinical measure used to ensure correct activation of the TA was to observe a slight drawing-in maneuver of the lower part of the anterior abdominal wall below the umbilical level, consistent with the action of this muscle. In addition, a bulging action of the multifidus muscle should have been felt under the physical therapist's fingers when they were placed on either side of the spinous processes of the L4 and L5 vertebral levels, directly over the belly of this muscle [41].

### 2.6.2. General exercise

This exercise activates paravertebral and abdominal muscles. Because this exercise impose extra loading on

the spinal tissues, the general exercise was selected on the basis of maximizing the contraction benefit/spinal loading ratio, according to recommendations provided from recent experimental studies [31].

### 2.6.3. Sample size estimation

The required sample size (approximately 22 per group) was determined, assuming a type I error probability of 5 percent, a type II error probability of 10 percent, and 15 percent dropout based on the expected change in the clinical measures of muscle thickness, activity limitation and pain.

## 2.7. Data analysis

Data were analyzed using SPSS 11 (SPSS Inc, Chicago, Illinois). Kolmogorov-Smirnov test for normality was performed for all outcome variables. For parametric data independent and paired *t*-tests and for non-parametric data Mann-Whitney U and Wilcoxon tests were used for comparison between pretreatment and post treatment test results between groups and within groups, respectively. A *p*-value lower than 0.05 was accepted as being statistically different.

## 3. Results

Table 1 shows some of the demographic characteristics of the patients. There were no pre-treatment differences between two groups in any of these measures ( $P > 0.05$ ). Figure 1 presents the recruitment strategy and experimental plan. Out of 63 referrals to the trial, 58 patients met the inclusion criteria. Clinical assessment identified that the motor control exercise was not suitable for 5 patients. Fifty-eight patients were randomly assigned to two groups. Nine patients due to time limitations (2 in each group), not completed

Table 2  
Mean and standard deviations of study variables, *p*-value of within group comparisons and *p* value for difference between groups

Outcome measures	Motor control group ( <i>n</i> = 25)			General group ( <i>n</i> = 24)			<i>P</i> value <sup>d</sup>
	Before	After	<i>P</i> value <sup>c</sup>	Before	After	<i>P</i> value <sup>c</sup>	
TA <sup>a</sup> thickness (mm)	1.87 ± 0.63 <sup>b</sup>	2.39 ± 0.63	0.0001	1.93 ± 0.49	2.22 ± 0.47	0.0001	0.005
MF <sup>a</sup> thickness (mm)	8.63 ± 2.37	9.69 ± 2.49	0.0001	8.83 ± 1.53	9.26 ± 1.56	0.0001	0.004
Pain (ordinal)	7.25 ± 0.97	2.5 ± 1.24	0.0001	8 ± 1.21	4 ± 1.54	0.0001	0.83
AL <sup>a</sup> (total scores) (ordinal)	8.83 ± 3.38	5.42 ± 2.43	0.0001	10.67 ± 2.81	7.25 ± 2.73	0.0001	1
Sock test	1.33 ± 0.89	0.58 ± 0.67	0.007	1.75 ± 0.62	1.08 ± 0.29	0.005	0.84
Pick up test	1.75 ± 0.75	0.83 ± 0.58	0.005	2.25 ± 0.62	1.25 ± 0.87	0.001	0.76
Roll up test	1.75 ± 0.87	1.33 ± 1.15	0.025	2.08 ± 1.16	1.67 ± 1.07	0.025	1
Fingertip to floor test	1.58 ± 0.9	0.92 ± 0.67	0.005	1.92 ± 0.99	1.08 ± 0.79	0.004	0.59
Lift test	2.42 ± 0.67	1.75 ± 0.62	0.011	2.67 ± 0.49	2.17 ± 0.72	0.014	0.63

<sup>a</sup>TA = Transversus Abdominis, MF = Multifidus, AL = Activity limitations.

<sup>b</sup>Values are Mean ± Standard Deviation.

<sup>c</sup>Statistical different at *P* < 0.05.

<sup>d</sup>*P* value for difference between groups.

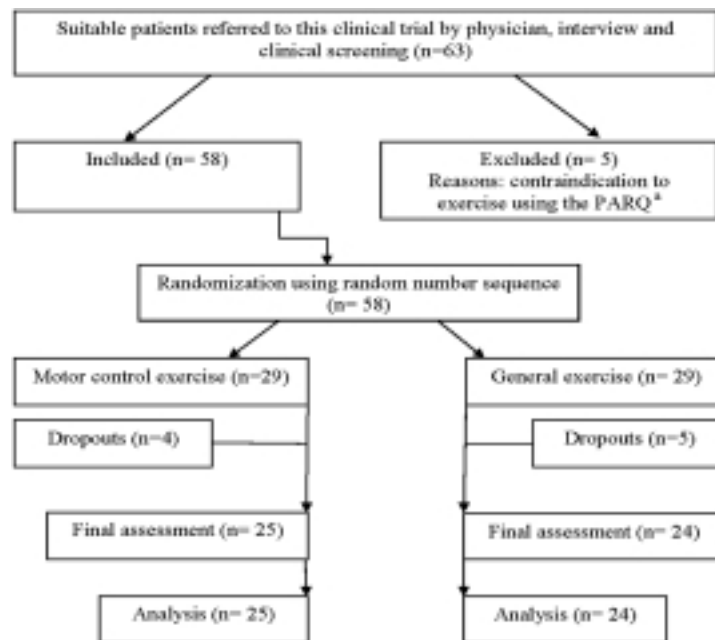


Fig. 1. Flow diagram of the progress through the phases of the randomized trial. <sup>a</sup>Physical activity readiness questionnaire.

treatment (3 in motor control and 1 in general group), and pain exacerbation (1 in general group) were excluded. Forty-nine patients (25 in motor control and 24 in general group) completed the full program.

Before and after intervention, mean and standard deviation of study variables, *p*-value of within group comparisons and also comparison of mean difference between two groups and its *p*-value are shown in Table 2.

### 3.1. Within group comparison

Paired *t*-tests revealed significant difference in the groups, with an increase in TA and LM thickness, de-

crease in pain and activity limitation (*P* < 0.0001). Wilcoxon tests also identified significant difference within groups regarding BPS's subgroups scores (*P* < 0.05) (Table 2).

### 3.2. Between group comparisons

Before treatment, an independent *t*-test identified the difference between the motor control and general exercise groups in terms of pain (*P* = 0.11), TA thickness (*P* = 0.77), LM thickness (*P* = 0.8), activity limitations (*P* = 0.16), sock (*P* = 0.24), pick-up (*P* = 0.16),

roll-up ( $P = 0.29$ ), fingertip-to-floor ( $P = 0.44$ ), and lift ( $P = 0.44$ ) was not significant. Therefore, both groups were matched regarding pain, muscle thickness, activity limitations, and its subgroups. After treatment, an independent *t*-test also identified the difference between the motor control and general exercise groups in terms of TA thickness ( $P = 0.45$ ), LM thickness ( $P = 0.61$ ), activity limitations ( $P = 0.096$ ), sock ( $P = 0.06$ ), pick-up ( $P = 0.27$ ), roll-up ( $P = 0.51$ ), fingertip-to-floor ( $P = 0.63$ ), and lift ( $P = 0.19$ ) was not significant. However, after treatment, the mean score of pain significantly decreased in the motor control group compared with the general exercise group ( $P = 0.015$ ).

The differences between pretreatment and post treatment measurements were calculated as the improvement ratio in both groups. The improvement ratio of TA ( $P = 0.005$ ) and LM ( $P = 0.004$ ) in the motor control group was greater than the improvement ratio in the general exercise group. However, no significant difference was seen between groups in terms of other variables ( $P > 0.05$ ) (Table 2).

#### 4. Discussion

The results of this study support the initial hypothesis that motor control exercise is effective in increasing TA and LM thickness and both protocols also decrease pain and activity limitation in patients with chronic LBP. However, the general exercise also increased TA and LM thickness. Sock, pick-up, roll-up, fingertip-to-floor, and lift tests scores improved following both protocols. There was no significant difference between two groups in terms of study variables, but the motor control exercise decreased pain more than the general exercises. Finally, the improvement ratio of TA and LM thickness in the motor control group was greater than the improvement ratio in the general group. Although, on the results of within and between group comparisons, this finding should be carefully interpreted.

Without any definitive proof from a relevant RCT, some authors believe that all patients with LBP may benefit from spinal stabilization exercise retraining on the premise that deconditioning of trunk muscles leads to instability symptoms [16,37,41]. Because of parameters variability, there are many controversies among recent studies and their results. So, a suitable comparison is not probable between studies. Koumantakis et al. found that the general exercise reduces disability and pain in the short term than a stabilization-enhanced

exercise [27]. Our study was similar to Koumantakis one. However, they used a combination of stabilization and general exercises only in one group. We studied parameters which were different from Koumantakis study parameters. Pain also evaluated with two different scales. In contrast with Koumantakis et al., we found that pain significantly decreased in motor control group compared with the general group. Contrary to Hides et al. [20] and other theories that will be discussed later, our study revealed that TA and LM thickening and activity limitations decreasing were similar in both groups. An increase in muscles thickness and a decrease in activity limitations were seen after both protocols. On the other hand, and in line with Koumantakis et al., we also believe that stabilization exercises do not provide additional benefit to patients with chronic LBP who have no spinal instability. However, O'Sullivan et al. demonstrated that stabilization exercises are more effective in reduction of pain and disability than general exercises [36]. So, along with other researchers, we recommend a RCT using our protocols and measures in these patients. Hides et al. reported that specific exercise therapy in addition to medical management may be more effective in reducing LBP recurrences than medical management and normal activity alone in acute, first-episode LBP patients [20]. In contrast with previously mentioned studies and our results, Danneels et al. demonstrated positive results for multifidus muscle CSA increase in favor of one of the general exercise methods [12].

While there several opinions regarding the effectiveness of lumbar local stabilizing muscles exercises in chronic LBP patients in recent researches and present study [12,27], in line with our results, other studies also have emphasized on the effectiveness of this exercise in LBP patients who have lumbar instability [27]. Probably, these views can be the reason of pain relief and more thickening of TA and LM in the motor control group in our study. Although, because of no difference between the posttreatment results of both groups, we cannot rely on this improvement, so, it has not importance. The stabilization function of any antigravity trunk muscle is likely to be affected in LBP patients. Their tonic fibers have an important antigravity, postural supportive role [40]. These fibers can be affected by disuse [39] and by the reflex and pain inhibition [5] associated with lumbar pain and injury. The nature of this dysfunction impacts on the type of exercise required to restore this stabilizing or supporting role [40]. On this basis and other reasons that will be explained, antigravity trunk muscle training can be one

of the most common causes of pain reduction. So, we should find the reasons of controversy in other aspects of studies. Several researchers have demonstrated dysfunctions in LM of back pain patients [20]. Rantanen et al. demonstrated 'moth eaten' type I muscle fibers in the multifidus muscle of patients with chronic back pain [38]. Biederman et al. found that LM demonstrate greater fatiguability relative to other parts of the erector spine in chronic back pain patients compared with a normal population [7].

In addition to previously mentioned reasons, we believe that the motor control exercises result in greater improvement in LBP patients because of tendency of patients to adopt a strategy for increased stiffness and stability at the expense of spinal function [48], critical role of deep muscles in control of intervertebral motion with the potential advantage of allowing dynamic control of the spine [23,24,28,43,52], changes in the strategy for control of the trunk muscles [21,22], and non-resolution of changes in the deep muscle system [20]. The key feature of the motor control exercise is the training of the deep trunk muscles in isolation before progressing to demanding tasks that train coordination of the deep and the superficial trunk muscles [41].

The premise of the motor control approach is that simple functional exercise alone does not re-establish coordination of the trunk muscles. This premise is supported by the finding that the adaptation of these muscles to pain is still present following recovery from an episode of LBP, when patients have returned to normal functional levels [21,22]. Furthermore, recent data confirm that coordination of the abdominal muscles can be restored with training of specific activation of the trunk muscles [47]. Finally, non-resolution of muscle dysfunction is associated with increased back pain recurrence [20].

## 5. Conclusion

The findings support that the motor control and general exercises are effective in increasing TA and LM thickness and reducing pain and activity limitation in patients with chronic LBP without any signs of instability. However, the motor control exercises are more effective in reducing pain than the general exercises.

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