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Stabilization Exercises *versus* Flexi-Bar Exercises in Chronic Non-Specific Low Back Pain: Pain, Disability, Back Muscles Endurance. A Randomized Controlled Trial

F. Amiri[1], M. Mohsen Roostayi[1], S. S. Naimi[1], A. Akbarzadeh Baghban[2]

[1] *Department of Physiotherapy, Physiotherapy Research Center, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[2] *Proteomics Research Center, Department of Biostatistics, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

CORRESPONDING AUTHOR:
Mohammad Mohsen Roostayi
Department of Physiotherapy
Physiotherapy Research Center
School of Rehabilitation
Shahid Beheshti University of Medical Sciences
Damavand Street
Tehran, Iran
E-mail: roosta@sbmu.ac.ir

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SUMMARY

Background. Low back pain (LBP) is one of the most prevalent and costly musculoskeletal problems. Impaired neuromuscular control and reduced use of the dorsal and abdominal muscles lead to instability in the spine and subsequent injury. Recently, vibration therapy has been proposed as an alternative method for LBP rehabilitation. Flexi-bar is a vibratory tool. When it is shaken, the core muscles are automatically activated to control the trunk against oscillatory forces created by the Flexi-bar. This study aimed to compare the efficacy of Flexi-bar and stabilization exercises in LBP rehabilitation.

Methods. Thirty-eight patients were randomly assigned into Flexi-bar (n = 19) and stabilization (n = 19) groups. The Flexi-bar group received general physiotherapy and Flexi-bar exercises and the stabilization group received general physiotherapy and stabilization exercises. Both groups received treatment for 3 sessions per week, a total of 10 sessions. The outcome measures were Numeric Pain Rating Scale, Oswestry Disability Index, and Sorensen test.

Results. After the intervention, both groups showed a significant improvement in pain, functional disability, and back muscles endurance ($p < 0.05$) however, no significant differences were found between the groups after treatment, while only back muscles endurance was significantly improved in the Flexi-bar group over the stabilization group ($p < 0.001$).

Conclusions. Neither of the two exercise interventions wasn't superior in reducing pain and functional disability. However, the Flexi-bar group showed significant improvement in back muscles endurance over the stabilization group. Flexi-bar is recommended as an effective, portable, and cheap tool in LBP rehabilitation.

Study registration. This study was registered in the Clinical Trial Center with no: IRCT20191015045122N1.

KEY WORDS

Back muscles endurance; chronic non-specific low back pain; flexi-bar; stabilization exercise; vibratory stimulation.

INTRODUCTION

Low back pain (LBP) is one of the most the most prevalent and costly musculoskeletal problems that annoys more than 80% of people at least one time in their life and interferes with their individual and social life (1, 2). Due to the studies, 90% of LBPs are non-specific, which is recognized as LBP without particular sources of pain and no evidence of pathology and abnormality with imaging (3-5). Also, if its pain remains more than 12 weeks between the 12th rib and the gluteal fold without leg pain (5), it is named chronic non-specific low back pain (CNLBP). CNLBP is a complex problem in which patients experience limited mobility due to prolonged pain (more than 3 months) (6). On the other hand, low mobility causes musculoskeletal complications (7) such as muscle weakness and this aggravates the pain. Evidence has suggested changes in timing and muscular recruitment patterns in patients with LBP (8). Impaired neuromuscular control and reduced use of the dorsal and abdominal muscles lead to instability in the spine and subsequent injury (9). Also, studies have shown lumbar multifidus atrophy in patients with CLBP (10). In addition, tissue changes in muscle, such as the conversion of type I to type IIC fiber, have been identified in CLBP (11). There is increasing recognition that stabilization exercise is popular in the management of pain and functional disability of patients with CNLBP (12). The purpose of stabilization exercise is to improve neuromuscular control and endurance of the trunk muscles (13).

Recently, vibratory stimulation has been proposed as an alternative method for LBP rehabilitation. since it reduces pain and improves functional disability (14). Flexi-bar is a vibratory tool that consists of an elastic bar of around 152 cm in length and produces vibration at a low frequency of 5 Hz when it is actively moved (15). It has been progressively used to train strength, endurance, coordination, balance, proprioception, and joint stability (16, 17). This tool automatically activates local (multifidus, transverse abdominis, and internal oblique) and global core muscles (rectus abdominis and erector spine) to control the trunk against oscillatory forces created by the Flexi-bar (18, 19). Chung *et al.* (20) compared the effect of stabilization exercises with and without Flexi-bar on pain and functional disability of patients with CLBP. They reported that the pain and functional disability were significantly improved in both groups. But stabilization exercises with Flexi-bar had significantly reduced pain and functional disability compared to non-Flexi-bar stabilization exercises. Despite the advantages of stabilization exercises, patients cannot perform these exercises without a supervised therapist at home so, we hypothesized Flexi-bar as a portable, convenient, cheap, and safe tool that can be used instead of stabilization exercises at home. Therefore, the purpose of the present study was to compare the efficacy of Flexi-bar and stabilization exercises on pain, functional disability and, back muscles endurance of patients with CNLBP.

MATERIALS AND METHODS

Study design

This study was a randomized controlled trial which was conducted at physical therapy clinic of Shahid Beheshti University between November 2019 and March 2020. Prior to the study, patients signed an informed consent form which was approved by the Ethics Committee of Shahid Beheshti University with no: 1398.341 in October 2019. The authors declare that the procedures were followed according to the regulations established by the Ethics Committee and to the Helsinki Declaration of the World Medical Association.

Sampling and randomization

The sample size was taken from a pilot study included 10 patients with the same inclusion and exclusion criteria. Assuming the type 1 error of 0.05, the test power of 90% according to a pilot study on 5 samples in each group, the final sample size was determined 19 patients in each group, and a total of 38 people were identified. Patients were randomly assigned into two groups by an independent researcher. The allocation was achieved using numbered sheets: (1 corresponding to the Flexi-bar group and 2 corresponding to the stabilization group), inside sealed envelopes picked up by the patients before baseline data collection.

Participants

In this study 42 patients with CNLBP were screened for eligibility criteria by a physiotherapist and 38 patients with CNLBP were enrolled. After checking the inclusion and exclusion criteria, an interview was conducted with patients. All the patients were fully informed about the study, and they signed an informed consent at the beginning of the study, which was approved by the Ethics Committee of our University. Inclusion criteria were local pain in the lumbar spine (between the first lumbar vertebra and gluteal fold), chronic or repeated pain for more than three months, age between 20 and 45 years, minimum pain 3 out of 10 based on the Numeric Pain Rating Scale (NPRS) index. Patients who had undergone spinal, upper or lower extremities surgeries, neurological, orthopedic, and vestibular disorders, cardiovascular or respiratory diseases, diabetic neuropathy, and body mass index (BMI) over 25 were excluded.

Interventions

Patients allocated to both groups received supervised treatment sessions by a physiotherapist.

First, both groups received 20 minutes of general physiotherapy treatment including transcutaneous nerve electrical stimulation (TENS), infrared (IR), and ultrasound. Second, both groups Performed a warm-up period (4 stretching exercises for 5 min) at the beginning of every session. After that, exercises commenced with simple movements and progressed to more difficult exercises. The patient was allowed to go to the next stage if the previous stage was performed completely and according to the relevant protocol. Finally, both groups performed a cool-down period (4 stretching exercises) at the end of every session. The frequency of exercise for both groups was 3 sessions per week, a total of 10 sessions. The patients were instructed to perform their exercises as much as they could. However, the net exercise time was defined to be 20 min for each group but it depends on the patient's ability.

Flexi-bar exercises program

A practice was conducted to familiarize patients with the Flexi-bar device before the experiment, for instance, patients should always hold the Flexi-bar in the center of the rubber grip and keep grip relaxed at all times with wrists in a neutral position. In other words, try not to squeeze the grip. Additionally, while shaking the Flexi-bar, the more rigidity that can be maintained in the arm, the greater is the amplitude of the training. The Flexi-bar exercises should be done with as little trunk movement as possible. Patients performed each Flexi-bar exercise for 30-60 seconds and rested for 90 seconds but the swing duration was dependent on the strength, coordination capabilities, and fitness level of the patients. The Flexi-Bar exercises comprise eight programs, including chest and back, lower back and chest, deep back extensors, core muscles, multifidus (deep vertebral stabilizing muscles), torso musculature, bottom (glutes), bottom (**table I**).

Stabilization exercises program

In this group, the anatomy and function of the transverse abdominal muscle were explained to patients. Recognition of this muscle's contraction was taught in the first sessions. To ensure accurate contraction of the transvers abdominis muscle, it was explained to the patients that by the contraction of this muscle the lower part of the anterior abdominal wall under the umbilical level will be "drawn in". Then, low-intensity isometric contraction of this muscle in minimally loading positions was ordered. Gradually, integration with dynamic activities was instructed. The stabilization exercises comprise six programs, abdominal drawing-in at the supine position, abdominal drawing-in with heel slides, abdominal drawing-in with bridging, abdominal drawing-in with single leg bridging, bird-dog exercise, and supine dead bug. For making the number of times and set identical, each exercise was held ten times ten sets (**table I**).

Measurements

The outcome measures were assessed at baseline and after 10 treatment sessions by a physiotherapist.

Pain

In this study, NPRS was used to measure pain intensity. NPRS has high validity and moderate reliability in pain assessment (21). In this scale, the zero number indicates the absence of pain, the 1-3 numbers indicate mild pain (slight interference with ADL), the 4-6 numbers indicate moderate pain (significantly interferes with ADL), the 7-10 numbers indicate severe pain (disability and inability to perform ADL) (22).

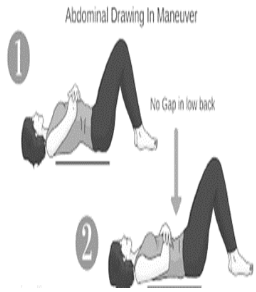
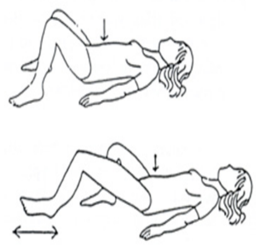
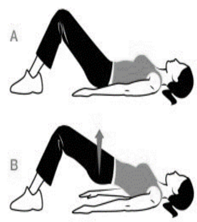
Functional disability

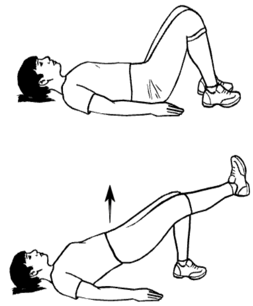
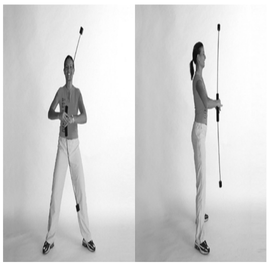
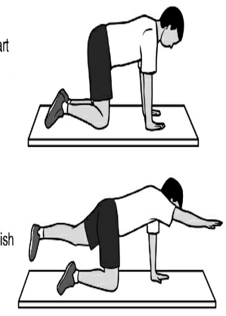
The Oswestry Disability Index (ODI) is a very important tool that researchers used to measure the patient's functional disability. This test is considered a "gold" standard and contains questions related to functional activities including pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex, social life, and travel. The interpretation of this scale is 0 to 20% for the minimum disability, 21 to 40% for the moderate disability, 41 to 60% for the severe disability, 61 to 80% for the disabled, and 81 to 100% for the hospitalize (23).

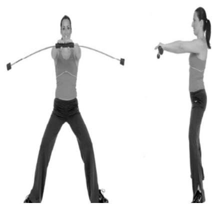
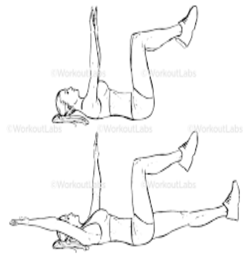
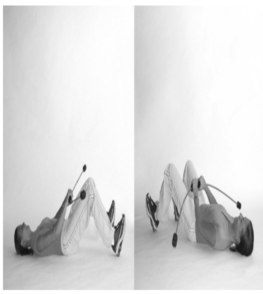
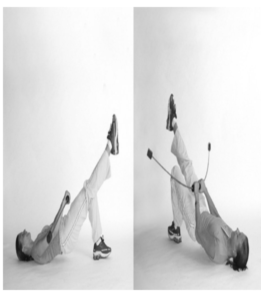
Back muscles endurance

To test back muscles endurance, we used the Sorensen test. First, the patient should sleep in the prone position, with the lower half of the body below the ASIS on the bed, the patient is fixed to the bed by three straps from the ankle, knee, and greater femoral trochanter. Before the test, the patient is allowed to rest his or her upper body on a chair. Next, the patient is asked to lift the upper torso off the chair and place the arms crosswise on the chest. After that, as long as possible, the patient should keep the torso in a normal alignment. Finally, the therapist calculates this time. During the test, while the patient is holding a horizontal position, a series of small movements occur naturally that the therapist may consider being the cause of fatigue. To prevent such errors, deviation of more than 10 degrees in the sagittal plane is a sign of fatigue and intolerance of the patient to hold the position (24). This test was taken three times with a rest interval of 1 minute and finally, their mean was calculated.

Table I. Exercises program.

Flexi-bar exercises		Stabilization exercises	
Chest & back: stand with your legs separated by your shoulder width. Grasp the handle from above, in front of your body then, swing it forward and backward (30-60 seconds)		Abdominal drawing-in at the supine position: lie on your back with your bending knees. Squeeze your stomach muscles without pressing your back flat to the floor. Hold for 10 s, counting aloud to avoid holding your breath. (10 repetitions)	
Lower back & chest: stand in a squat position with your knees and toes pointing outward, lean your upper body forward and keep your back straight, grasp the handle from above then, swing it up and down in the direction of the floor (30-60 seconds)		Abdominal drawing-in with heel slides: lie on your back with bending knees as in previous exercise. While tightening your stomach muscles (abdominal drawing-in), slide the heel of one foot away from you until your knee is straight (3 s count). Then, slide your heel back until your knee is in its original bent position (3 s count). Relax and repeat on the opposite leg (10 repetitions for both leg)	
Deep back extensors: stand in a squat position with wide legs, hold the flexi-bar above your head with extended arms then, swing it up and down (30-60 seconds)		Abdominal drawing-in with bridging: lie on your back with knees bent. While tightening your stomach muscles (abdominal drawing-in), tighten your buttocks and slowly lift them off the floor. Do not allow your back to arch. Hold for 10 seconds (10 repetitions)	

Flexi-bar exercises		Stabilization exercises	
Bottom: stand in a deep squat position, grasp the flexi-bar with both hands from above then, raise both arms to head height and swing it forward and backward (30-60 seconds)		Abdominal drawing-in with single leg bridging: lie on your back with knees bent. While tightening your stomach muscles (abdominal drawing-in), tighten your buttocks and slowly lift your buttocks off the floor then, straighten one knee so that only one foot is on the floor. Hold for 10 seconds (10 repetitions)	
Core muscles: stand with your legs more than your shoulder-width apart, hold the flexi-bar vertically and in front of your body then, swing it from left to right (30-60 seconds)		Bird-dog exercise: start on your hands and knees. Tighten your stomach muscles. First, lift your right arm from the table. Hold for 10 s. Return to starting position and repeat it for the left arm. Second, tighten your stomach muscles and then extend your right leg so that your knee is lifted from the table. As you do this, keep your hips level with the table. Hold for 10 s. Return to the start position and repeat for the left leg. After that, tighten your stomach muscles and extend your right leg so that your knee is lifted from the table, and lift your left arm from the table at the same time as you do this, keep your hips level with the table. Hold for 10 s. Return to start position and repeat with left leg and right arm. (10 repetitions)	

Flexi-bar exercises	Stabilization exercises
Multifidi (deep vertebral stabilizing muscles): stand with wide-leg squat position, hold the flexi-bar from above and bring your extended arms up to chest height then, swing it up and down (30-60 seconds) 	Supine dead bug: lie on your back with the hips and knees at 90 degrees flexion and the arms at 90 degrees flexion. First, perform an abdominal drawing-in maneuver and maintain it throughout the exercise. Then raise the right arm above the head and flatten it completely. At the same time, raise and flatten the left leg to the ground, then return to the starting position and repeat this exercise for the left arm and right leg (10 repetitions) 
Torso musculature: lie on your back with bending knees and the place your heels on the floor. Hold the flexi-bar with extended arms then, swing it forward and backward, parallel to your thighs (30-60 seconds) 	
Bottom (glutes): lie on your back with knees bent. Tighten your buttocks and slowly lift your buttocks off the floor then, straighten one knee so that only one foot is on the floor. Grasp the handle from above, extend your arms completely then, swing it forward and backward, parallel to your thigh (30-60 seconds) 	

Statistical methods

All the analyses were performed using SPSS software version 25 on a personal computer. First, we used the non-parametric Kolmogorov-Smirnov test (K-S test) for checking the normality of the data. Next, an independent-sample t-test was used to assess if there were any significant differences between the two study groups in demographic characteristics and baseline values of NPRS, ODI, and Sorensen test (**table III**). Then, the paired t-test was used to assess NPRS, ODI, and Sorensen test in the Flexi-bar group (before and after treatment) and the stabilization group (before and after treatment) (intragroup study). Finally, analysis of covariance (ANCOVA) was used to test the significance of changes in scores of NPRS, ODI, and Sorensen test between two groups before and after treatment (intergroup study). A P-value of 0.05 or less was suggested to be significant.

RESULTS

Of 42 eligible patients, 2 patients were excluded from the study due to lack of inclusion criteria and 2 patients were excluded from the study due to unwillingness to continue treatment. Finally, 38 patients (19 males, 19 females; mean age: 33.82 ± 6.2 years; range, 20 to 45 years) completed the study. Participants flow shown in **figure 1**. The descriptive and baseline characteristic of patients have shown in **table II**. To find which one of the two different approaches is more effective, we compared the NPRS, ODI, and Sorensen test before and after the intervention. **Table III** indicated that before the intervention, there were significant differences between two groups in NPRS ($p = 0.04$), ODI ($p = 0.001$) and, Sorensen test ($p = 0.001$) variables. After the intervention, the analysis of the paired t-test showed significant improvement ($p < 0.05$) in all variables in each group (intragroup study) (**table IV**) however, the analysis of covariance (**table V**) indicated no significant differences in NPRS ($p = 0.06$) and ODI ($p = 0.29$) variables between two groups but, the Flexi-bar group did significantly better in back muscles endurance in comparison with stabilization group ($p < 0.001$).

DISCUSSION

The purpose of the present study was to compare the efficacy of Flexi-bar exercises and stabilization exercises on pain, functional disability, and back muscles endurance in CNLBP patients. According to the results of the study, after 10 sessions of intervention in both groups, pain intensity, functional disability, and bake muscles endurance were significantly improved. In patients with CNLBP, several causes such as that weakened or insufficient motor control in the deep trunk muscles and poor coordination, poor proprioception related to persistence LBP can lead to abnormal intersegmental movement in the spine. Finally, these factors can result in increased pain intensity and functional disability (25).

This study found the effectiveness of stabilization exercises in decreasing pain intensity and functional disability. This decrease may be due to re-education and increasing muscles strength as well as, restoring the neuromuscular system's ability to control the spine, thereby preventing injury during functional tasks (25, 26). Hence, these factors may result in decreased pain and functional disability. The results are in agreement with the systematic review study of Mueller *et al*. in which they declared that exercises are superior to other interventions in the treatment of CLBP. Specifically, the effect of stabilization exercises on the reduction of pain and functional disability (12). Due to Dohnert's study stabilization exercises showed better results in activating lumbopelvic stabilizing muscles over McKenzie exercises (27). However, the results are in disagreement with those of Koumantakis *et al*., in that, they found adding stabilizing exercises to general exercises in acute and chronic phases did not further reduce pain and disability (28). This difference may be due to the methodological variations, including the number of subjects, different exercises, and different intervention period.

According to the present study, Flexi-bar exercises were effective in reducing pain intensity and functional disability. This improvement is more likely due to the fact that when A-delta or C fibers transmit pain to the posterior horn of the spinal cord, it does synapses with the interneuron in the gray matter. After the synapse, the interneuron crosses to the anterolateral horn of the spinal cord and goes to the higher centers. Vibrational stimulation provokes the mechanical receptors such as Pacini and Meissner, which sense the vibrations, then A-beta myelinated fibers transmitted this sense of vibrations to the posterior horn of the spinal cord and suppresses pain transmission to the higher centers (29). Also, vibrational stimulation reduces the level of P substance in the CSF and has a neurophysiological placebo effect that reduces pain transmission from peripheral receptors to the brain (30). Additionally, vibratory stimulation triggers a tonic vibrational reflex (TVR). This reflex facilitates muscle contractions by increasing alpha motor neurons excitation through the activity of muscle spindles and polysynaptic

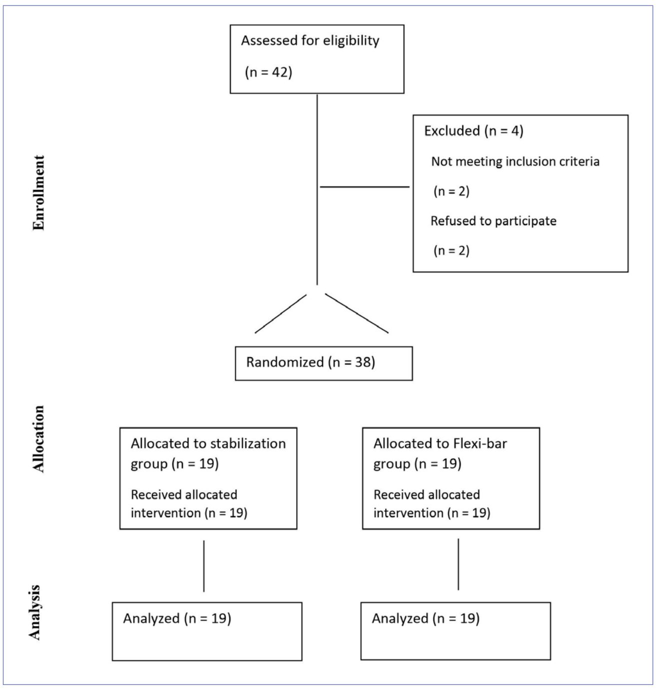


Figure 1. Study flowchart.

Table II. Baseline demographic characteristics of study population.

Variable	Stabilization group (n = 19)	Flexi-bar group (n = 19)	P-value
	Mean ± SD	Mean ± SD	
Age (year)	32.4 ± 7.6	35.2 ± 5.6	0.18
Height (cm)	174.3 ± 12.4	171 ± 7.04	0.32
Weight (kg)	72.4 ± 11.4	68.5 ± 7.7	0.23
BMI (kg/m²)	23.7 ± 0.9	23.4 ± 1.6	0.48

SD: standard deviation; BMI: body mass index.

Table III. Comparison of outcome measures before intervention between groups: independent-sample t-test.

Variable	Stabilization group (n = 19)	Flexi-bar group (n = 19)	P-value
	Mean ± SD	Mean ± SD	
NPRS (0-10 cm)	5.4 ± 1.3	4.5 ± 1.2	0.04
ODI (0-100%)	32.4 ± 8.8	23.4 ± 7.6	0.001
Sorensen (S)	18.3 ± 15.4	51.2 ± 34.9	0.001

SD: standard deviation; NPRS: Numerical Pain Rating Scale; ODI Oswestry Disability Index.

Table IV. Comparison of outcome measures within groups: paired t-test.

Variable	Flexi-bar group (n = 19)		P-value	Stabilization group (n = 19)		P-value
	Before	After		Before	After	
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
NPRS (0-10 cm)	4.5 ± 1.2	1.7 ± 1.5	< 0.001	5.4 ± 1.3	2.9 ± 0.9	< 0.001*
ODI (0-100%)	23.4 ± 7.6	11.04 ± 6.8	< 0.001	32.4 ± 8.8	14.4 ± 11.04	< 0.001*
Sorensen (S)	51.2 ± 34.9	84.5 ± 34.01	< 0.001	18.3 ± 15.4	35.2 ± 13.9	< 0.001*

*p < 0.05; SD: standard deviation; NPRS: Numerical Pain Rating Scale; ODI Oswestry Disability Index.

Table V. Comparison of outcome measures between groups: analysis of covariance.

Variable	Stabilization group (n = 19)	Flexi-bar group (n = 19)	P-value
	Mean ± SD	Mean ± SD	
NPRS (0-10 cm)	2.9 ± 0.9	1.7 ± 1.5	0.06
ODI (0-100%)	14.4 ± 11.04	11.04 ± 6.8	0.29
Sorensen (S)	35.2 ± 13.9	84.5 ± 34.01	< 0.001*

*p < 0.05; SD: standard deviation; NPRS: Numerical Pain Rating Scale; ODI Oswestry Disability Index.

pathways (31, 37), and the pain relief is a result of the synergistic effect through muscle strengthening (32). Obviously, these factors cause improvement in pain and functional disability. Our results are in line with those of Lee *et al.*, in that, they found a significant decrease in pain and functional disability after Flexi-bar exercises in the patient with LBP (30). Also, our results provide more evidence for Chung *et al.* study, in that, they indicated that stabilization exercises with Flexi-bar, significantly improved pain intensity and functional disability in the patients with CLBP (20).

In the comparison of the two groups, the present study showed no significant differences between groups in pain intensity and functional disability. The results are in agreement with those of Torabi *et al.*, in that, they examined the efficacy of stabilization exercises with and without whole-body vibration on pain and functional disability of patients with CNLBP. They found no significant improvement in pain intensity and functional disability between the two exercise interventions (23). But our findings do not support those of Chung *et al*. study, in that, they compared stabilization exercises with and without Flexi-bar on pain intensity and functional disability of patients with CLBP. They found stabilization exercises with Flexi-bar compared with stabilization exercises without Flexi-bar, significantly decreased pain and functional disability (20). Our results provide no evidence for those of Yang *et al*. study, in that, they found significant improvement in pain intensity of stability with the whole-body vibration group compared with the stability group (29). One possible explanation for no significant differences between the two groups of our study is that the intervention period of Chung and Yang studies was 18 sessions however, in our study the intervention period was 10 sessions.

Another purpose of the study was to examine the efficacy of stabilization and Flexi-bar exercises on back muscles endurance of CNLBP patients. Our study demonstrated that stabilization exercises were effective in improving back muscles endurance. This improvement may be related to the fact that during functional activity, decreased amplitude of multifidus muscles activity and delayed or decreased predictive response of paraspinal muscles in patients with LBP have been reported (33). Stabilization exercises with maximal or submaximal contraction have been suggested to prevent or reverse the type 2 atrophy of multifidus muscles and have a positive effect on the diameter of muscles fibers in patients with LBP (34). Kliziene *et al*. indicated that stabilization exercises enlarge the cross-sectional area of the lumbar multifidus in patients with CLBP (35). The results of the present study have also been observed in the previous study (33). However, the results are in disagreement with those of Sung *et al*. study, in that, they found no significant improvement in back muscles endurance in the stabilization group (36). This discrepancy may be due to the methodological variations, including the number of subjects, different exercises, and home exercises.

To our knowledge, this is the first study to examine the efficacy of Flexi-bar exercises on back muscles endurance in CNLBP patients. Our results showed that Flexi-bar exercises were effective in improving back muscles endurance. This improvement may be caused by the fact that during Flexi-bar exercises, vibration stimulation causes the muscle contraction by stimulating the tonic vibration reflex (TVR) and affecting the alpha motor neurons. Therefore, from a neurological point of view, the simultaneous involvement of more motor units leads to increase muscle strength (9, 37). So, this process enables the muscle to withstand a larger external load (38).

One interesting finding of the present study was that the Flexi-bar exercises significantly increased back muscles endurance over the stabilization exercises. This may be defined by the fact that when vibrations have been applied to an active muscle, they alter the neuromuscular patterns by changing the excitation level of the primary afferent (Ia) ending, this causes alpha motor neurons activation. On the other hand, vibrational stimulations are perceived not only by the muscle spindles but also by the skin, joints, and secondary terminals. These structures facilitate the gamma system by increasing the sensitivity of the Ia terminals. Vibrations not only affect the muscles that have been vibrated, but also the muscles on the opposite side and the adjacent muscles. The vibrations also activate the supplementary motor area, the Caudal cingulate motor area, and the 4^{th} brain region, which may affect the excitation level of peripheral and central structures of the brain to facilitate subsequent voluntary movements (39). Our results support those of Baard *et al*. study, in that, they found whole-body vibration exercises significantly improved back muscles endurance over the stabilization exercises (40). Vibration waves stimulate the primary ending of the muscle spindles and activate a large portion of the motor neuron in the neural pool, as a result, contract motor units that were previously inactive. This process leads to more efficient use of muscles to produce force. During whole-body vibration the activating mechanism of the motor neuron pool leads to further improvement in neuromuscular control by recruitment motor neurons that were previously inactive or fatigued, and even increasing their firing patterns (39, 40). According to these findings, Flexi-Bar can be useful in exercise prescriptions in the musculoskeletal disorders (41).

Study limitations

The first limitation was the inability to generalize the results due to the small sample size. Second, the lack of true blindness for the physiotherapist is due to the nature of the interventions. Third, we did not evaluate the effect of exercise on muscle function in these patients by the electromyography activity, which could give us a better view of the effect of the exercises. We recommend future studies investigating the electromyography activity of muscles, to better discuss and conclude about the effectiveness of exercises in these patients. Since the long-term effects of these exercise protocols cannot be predicted, future studies should perform follow-up.

CONCLUSIONS

According to the results of the study both Flexi-bar and stabilization exercises improved pain intensity, functional disability, and back muscles endurance in CNLBP patients. Our results suggested that neither of the two exercise interventions wasn't superior in reducing pain and functional disability. However, the Flexi-bar group showed significant improvement in back muscles endurance over the stabilization group. On the other hand, due to the fact that Flexi-bar is an effective, portable, and cheap tool, it is recommended to use it along with other stabilization exercises in LBP rehabilitation.

FUNDINGS
None.

DATA AVAILABILITY
Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS
FA: executive role. MMR: manuscript draft. FA, MMR, SSN: manuscript design; AAB: statistical analysis. All authors approved the manuscript and this submission.

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CONFLICT OF INTERESTS
The authors declare that they have no conflict of interests.

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