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The Effect of Adding High Threshold Suspension Training to Low-Load Motor Control Exercises on Pain, Function, and Swing Posture in Women with Chronic Nonspecific Low Back Pain: A Randomized Clinical Trial

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Original Article

Abstract

Introduction: Motor control exercises with low and high threshold is one of the newly introduced methods for the treatment of low back pain (LBP). The aim of present study was to compare the effect of adding suspended training with high threshold to motor control exercises (MCE) on pain, function, and postural sway in women with chronic nonspecific LBP.

Materials and Methods: 128 women with chronic nonspecific LBP with mean age of 38.4 ± 6.62 years were selected and divided into control (n = 43), MCE (n = 42), and MCE combined with suspension training (n = 43) groups. Visual analogue scale (VAS), movement control tests, and force distribution device were respectively used to assess pain, function, and swing posture (COPx and COPy) before and after 8 weeks of intervention. Paired t and one-way analysis of variance tests were used for data analysis ($P < 0.050$).

Results: MCE with and without suspension training showed significant effect on decreasing pain intensity ($P = 0.018$), postural sway ($P < 0.050$) and improving function ($P < 0.050$). It was also indicated that MCE combined with suspension training was more effective.

Conclusion: Findings of this study show addition of suspension training to MCE can improve pain, function, and swing posture in women with LBP with superior effect size. Regarding the improvement of the measured variables in the two training groups, it is suggested that a combination of these exercises be used in the treatment of patients with nonspecific chronic LBP.

Keywords: Motor control exercise; Suspension exercise; Postural sway; Low back pain

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Introduction

Low back pain (LBP) is one of the most common musculoskeletal disorders (MSDs) in industrialized societies, with a lifelong prevalence reported as 60 to 80% among individuals (1). LBP is divided into two types, specific and non-specific. A pathological problem in the structure of the spine which causes pain is referred to as specific LBP (2). In contrast, a LBP without an apparent cause is known as non-specific LBP, which is more common, in particular in women (2). Investigations have demonstrated that non-specific LBP is caused by factors including muscle weakness and imbalance, improper posture, impaired control of deep muscles [multifidus and transverse abdominal muscles (TVA)] and superficial muscles responsible for maintaining spinal stability, as well as spinal instability (3).

Impaired motor control, increased postural sway, and proprioceptive impairment are important problems in non-specific LBP (4). The proprioceptive impairment

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can cause problems such as defects in postural control and balance, leading to spinal disorders and instability (5). Previous studies have reported that subjects with chronic non-specific LBP suffer from more sway in body center of pressure (COP) in the anterior-posterior and internal-external directions in a static position compared to the healthy individuals (6), which can affect the patients' performance.

In recent years, the use of motor control exercises (MCEs) has expanded in people with LBP (3). These exercises improve motor control disorders in order to rewrite motor patterns, optimize movements, control spinal movements, and coordinate them with each other, in addition to strengthening and controlling the trunk muscles in individuals with LBP (3). Most MCEs are performed at low thresholds and intensities (7), while individuals perform daily tasks with high intensity under the frequent pressure of lifting heavy objects, which is itself a mechanism for developing LBP (8). Most high-threshold exercises, such as deadlifting, have been reported, however the results of using the deadlift exercise as a treatment for LBP have not been very satisfactory (9,10). Exercise with a high threshold includes suspension exercises such as total body resistance exercise (TRX), which have recently become very popular and are applied in training centers as a resistance exercise to train in unstable body positions (11,12).

Unstable training is a common method of resistance training used today in exercise and rehabilitation programs. Instability can be created using a variety of tools and techniques. Examples include the use of Swiss ball and Buso ball, on which weight training is performed (12). Based on the reports in studies, the use of MCEs improves pain and disability by applying the principles of motor learning to retrain trunk muscle control and correct posture and movement pattern (3). On the other hand, suspension training has been designed as a high-threshold resistance training in order to train in unstable situations (1,7) and is used to improve physical fitness and prevent and treat injury (10). This type of exercise changes how the muscles are used given the level of instability (13,14). Positive effects of the suspension exercise on pain, proprioception, strength, and function of people with LBP have been reported (8). These exercises increase the activity and contraction of the trunk muscles and seem to be very similar to the daily patterns of activity of normal and active people (12).

Based on the studies carried out on MCE and high-threshold suspension training, it appears that no investigation has been performed to compare the effects of these two training methods on pain, function, and postural sway in individuals with LBP. Therefore, this study is conducted with the aim to examine the effect of adding high-threshold suspension exercises to MCE on pain, function, and postural sway in women with non-specific chronic LBP. The researchers assumed that combining MCEs with suspension exercises could have a greater impact on pain, function, and postural sway.

Materials and Methods

The clinical trial consisted of three groups: MCE with suspension exercises, MCE without suspension exercises, and the control group. The study was reviewed and approved by the Research Ethics Committee, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran, with the code of ethics IR.MODARES.REC1398.118 and registered on the Iranian Registry of Clinical Trials (IRCT) with the clinical trial code UMIN000034930.

To determine the minimum number of samples, the software for estimating the statistical sample size (G*Power version 3.1.9.2) was employed. In order to conduct the study, given the necessity and considering the test power of 0.8 and the average effect size at the significance level of 0.05, the sample size was estimated to be about 135 (45 subjects in each group) (15). The subjects of the study were selected from women aged 35 to 45 years who had referred to physiotherapy clinics in Tehran with a complaint of LBP (history of pain for more than three months). To homogenize and select the samples, information such as age, activity level, smoking and alcohol consumption, and history of pain and injury in the lower back and lower limbs were first collected through questionnaires.

The study inclusion criteria were a diagnosis of non-specific LBP by the specialist, motor control impairment (at least two disorders in Luomajoki motor control tests) (16), and having a normal body mass index (BMI) (18 to 25 kg/m^2) (4) The specialist confirmed that none of the subjects had a history of surgery and fractures in the lower limbs and spine (17), inflammatory diseases (18), tumors (17), neurological disorders such as atrial system defects, neurological disorders (18), cancers (17), and pregnancy (17).

The eligible individuals were asked if they would like to participate in a study on training people with chronic non-specific LBP. Out of the individuals, 135 were selected and the research plan was fully explained to them. Prior to the study, written consent was obtained from all subjects. The subjects could also leave the study at any time without any explanation if they were not satisfied with the course of the project.

After obtaining the consent form from all participants, they were randomly divided into three groups of MCE (n = 45), MCE along with suspension exercises (n = 45), and control (n = 45). After the pre-test, the participants were randomly assigned to one of the three groups (two experimental groups and one control group) with a 1:1 ratio. The randomization was performed using sealed envelopes by a person who was not in contact with any of the subjects. The tasks of each group were written in the envelope. The training sessions for all three groups were held in a gym and the MCE and suspension exercises were performed individually. The testers were unaware of the division of the groups. The pretest was taken 48 hours before the start of the first training protocol session. After the pre-test, the motor control and motor control with suspension exercise groups performed the exercises 16 sessions in eight weeks (twice a week), and the control group performed the usual LBP exercises. Finally, 48 hours after the last session, the posttest was taken from the subjects in all three groups.

MCEs were derived from the intervention performed in the study by Aasa et al. (18). These exercises were designed individually on the basis of the pattern of movement causing the pain, besides, the exercises were selected individually with the goal of restoring the subjects' movements to their normal state. The exercises consisted of three stages, and each person would advance to the next stage if they completed the first stage and the pain was reduced (18). In the first stage, the movements were designed in the same way for different people. Moreover, the sessions were held twice a week each for 20 to 30 minutes, and the subjects performed the movements three times a day with at least 10 repetitions in two sets at home. At this stage, the subjects were taught to maintain the normal lumbopelvic joint position while lying on the chest, lying on the abdomen, standing position, sitting position, and on all fours position, and by moving their arms and legs, maintain the normal position of the joint and increase time and repetition by improving movement. The purpose of the first stage of the exercise was to maintain the normal position of the joint and the direction of the spine in the movements of the upper and lower limbs, pelvis, and shoulders. In the second stage, the most painful positions were identified for each person and different exercises were given in the same positions according to the movement patterns that caused pain in the lumbar region. The goal of this step was to reduce the high effort to do the movements, reduce stiffness, strengthen the stabilizing muscles, and control movement in the desired range of the joint. In the third stage, the individuals had to be able to maintain the normal position of the spine and the lumbopelvic joint in the dynamic movements, and perform the correct movement pattern that they used a lot during the day (Appendix 1). For example, the subjects learned to keep the spine in a normal position to perform the forward bending movement, and first use the flexion of the knee and thigh joint to bend forward, in addition to preventing the flexion of this section using the stabilizers of the muscles supporting the spine (18).

The suspension exercises were performed by TRX (16), which were the modified Dawes exercises (19). These exercises were designed individually and without any pain sensations, with the purpose to restore the individuals' movements to their normal state. In each session before and after and during exercise, the subjects had to report their pain. The first session focused only on performing the right motor patterns and movements as well as activating the stabilizing muscles. Each movement was 2 to 3 sets and the repetition progressed from 8 to 12, with 30 to 60 seconds of rest given between the sets (Appendix 2). 10 minutes of warm-up was performed at the beginning of each session and 5 minutes of gentle stretching movements was performed at the end of the sessions to cool down (16). LBP was measured using the visual analogue scale (VAS), which had a reliability coefficient of 0.91 and a validity reported as moderate to good (20,21). The subjects' specific function was assessed using the Patient-Specific Functional Scale (PSFS). In this section, each subject had to perform three important movements in which they encountered severe disability and defects due to LBP. The ability to perform the movement was given a score of 0 to 10 by the tester, with scores 0 and 10 indicating that the person was unable to move and that he was unable to perform activities at the pre-injury level, respectively (18). The reliability coefficient of PFPS was 0.97 and its validity [confidence interval (CI) = 0.71 (0.51-0.84)] was reported to be 95% (16).

General function measurements included a weight lifting test, a sprinter plank, a side plank, Biering-Sorensen test (22), and a set of motion control tests. For the weightlifting test, the maximum capacity [one-repetition maximum (1RM)] and the isometric lifting ability before the lift test were taken from the subjects and recorded in kg. In the sprinter plank, side plank, and Biering-Sorensen tests, the person was asked to keep the lumbar spine in the neutral position as long as he could.

Table 1. Demographic characteristics and number of subjects in each group

Variable	MCE + Suspension exercises (n = 42)	MCE (n = 43)	Control group (n = 43)	P value
Age (year)	38.60 ± 4.62	40.50 ± 1.57	41.40 ± 3.44	0.462
Height (cm)	68.60 ± 2.54	74.60 ± 5.46	69.50 ± 4.63	0.536
Weight (kg)	165.80 ± 3.59	169.80 ± 6.67	165.70 ± 7.54	0.469
Body mass index (kg/m^2)	25.20 ± 2.07	26.20 ± 20.02	26.20 ± 2.50	0.359

MCE: Motor control exercises
Data are reported as mean ± standard deviation (SD).

In order to measure the postural sway index in the present study, a pressure distribution device was utilized. Prerequisites for testing, such as calibrating the device and providing explanations about the overall test process were provided to each participant. The person was then asked to stand barefoot on the screen. In this case, the arms were hanging next to the body, the posture was in the normal position, and the legs (feet) were as far apart as the inter-anterior superior iliac spine (ASIS) distance. The COP signal was received and recorded in the two anterior-posterior and interior-interior directions using a force plate (Bertec, UK). The different states of recording the stability indicators on the force plate in the present study included two visual states (eyes open and closed) and randomly. The first time an individual was placed on the device, his footprints were recorded and he was placed in the same position the next times. In each task, three tests were performed, with a time of 30 s for each test and a one-minute rest time between two tests. In order to prevent errors, it was necessary to maintain the correct standing position at the beginning and end of the test (23).

The normal data distribution was assessed using the Shapiro-Wilk test. The repeated measures analysis of variance (ANOVA) test was employed to evaluate the interactive effect of time on the group and the independent t and paired t tests to investigate the intragroup and intergroup differences, respectively. Finally, the data were analyzed in SPSS software (version 20, IBM Corporation, Armonk, NY, USA) at a significant level of 0.05. The effect size (Cohen's d) was calculated as small (d = 0.20), medium (d = 0.50), and large (d = 0.80) effect size (24).

Results

The demographic characteristics and the number of subjects in each group are presented in table 1. 3, 2, and 3 subjects respectively in the MCE + suspension exercise, MCE, and control groups were excluded from the study due to non-participation in the post-test (Figure 1).

The interactive effect of time on the group in the variables of pain (P = 0.001, F = 43.231), function [specific function scale (P = 0.001, F = 32.621)], lifting power (P = 0.009, F = 67.437), sprinter plank (P = 0.007, F = 46.542), side plank (P = 0.018, F = 76.375), Biering-Sorensen (P = 0.027), F = 24.345), and postural sway [eyes-open sway range (P = 0.001, F = 48.270), eyes-open sway area (P = 0.004, F = 39.272), eyes-closed sway range (P = 0.007, F = 34.711), and eyes-closed sway area (P = 0.001, F = 45.123)] were significant. Table 2 demonstrates the pain changes in VAS in each group.

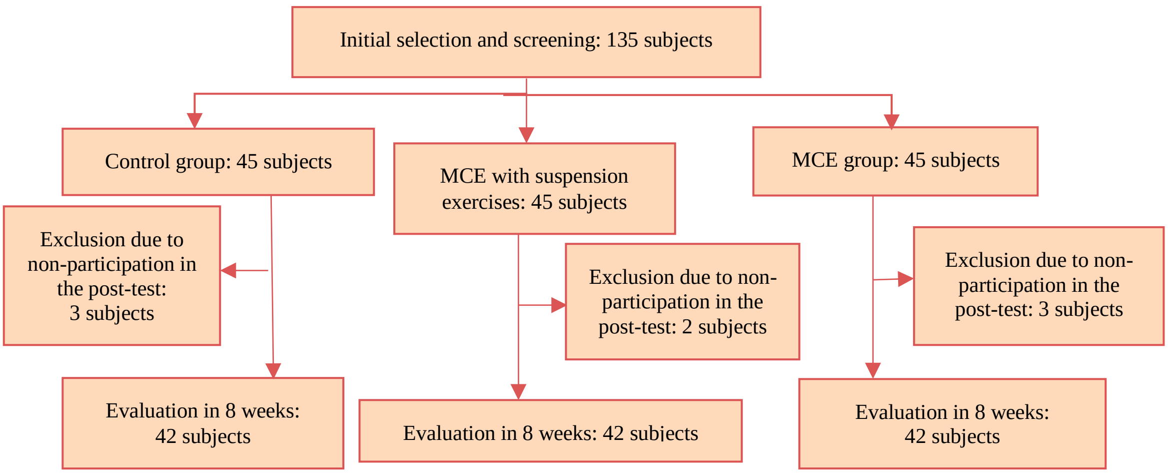

Figure 1. Assessment of eligibility, inclusion and exclusion criteria, and analysis

Table 2. Data on pain in the subjects

Variable	Test	MCE + Suspension exercises	MCE	Control group	P value (Covariance)
Pain (cm)	Pre-test	5.30 ± 1.05	5.10 ± 0.94	5.10 ± 1.21	0.314
	Post-test	2.30 ± 0.45	3.00 ± 1.09	5.50 ± 0.54	0.018*
	Intragroup changes (%)	56	41	7	-
P value (Paired t)		0.001**	0.017**	0.215	-
Size effect		0.750	0.638	-	

MCE: Motor control exercises
*Significant intergroup differences, **Significant intragroup differences, Data are reported as mean ± SD.

The paired t-test results showed significant intragroup changes in both groups of MCE with and without suspension exercises in all study variables, with the difference that the rate of changes in the group of MCE with suspension exercises was higher than the other group. Moreover, there were no significant changes in the control group (Table 3).

Changes in the postural sway in each group are presented in table 4.

Discussion

The present study was conducted aiming to investigate the effect of adding high-threshold suspension exercises to specific low-threshold MCEs in women with chronic non-specific LBP on the variables of pain, function, and posture sway. The results showed that adding the high-threshold suspension exercises to MCE had a greater effect on the pain, function, and posture sway of women with chronic non-specific LBP.

Table 3. Data on the performance of the subjects

Variable	Test	MCE + Suspension exercises	MCE	Control group	P value (Covariance)
Specific function (0 to 10)	Pre-test	4.20 ± 0.64	4.20 ± 0.43	4.10 ± 0.37	0.507
	Post-test	7.10 ± 1.42	6.30 ± 1.11	4.10 ± 0.51	0.003*
	Intragroup changes (%)	55	50	4	-
P value (Paired t)		0.001**	0.004**	0.659	-
Size effect		0.657	0.652	-	
Lifting power (Newton)	Pre-test	800.45 ± 65.60	812.53 ± 78.40	792.44 ± 73.20	0.422
	Post-test	980.56 ± 76.40	930.48 ± 65.50	784.66 ± 55.60	0.013*
	Intragroup changes (%)	22	14	1.04	-
P value (Paired t)		0.001**	0.002**	0.412	-
Size effect		0.657	0.648	-	
Sprinter plank (s)	Pre-test	24.30 ± 6.12	27.10 ± 3.47	28.40 ± 5.23	0.642
	Post-test	48.50 ± 5.52	41.50 ± 4.27	26.70 ± 6.90	0.021*
	Intragroup changes (%)	99	53	5	-
P value (Paired t)		0.003**	0.008**	0.611	-
Size effect		0.684	0.589	-	
Side plank (s)	Pre-test	22.70 ± 4.43	23.20 ± 4.95	25.30 ± 5.65	0.428
	Post-test	38.70 ± 6.54	34.60 ± 4.65	22.40 ± 5.59	0.012*
	Intragroup changes (%)	70	49	11	-
P value (Paired t)		0.001**	0.005**	0.458	-
Size effect		0.743	0.683	-	
Biering-Sorense (S)	Pre-test	45.70 ± 7.47	44.80 ± 7.47	47.40 ± 6.34	0.348
	Post-test	68.550 ± 6.62	61.60 ± 8.53	44.50 ± 8.65	0.014*
	Intragroup changes (%)	49	37	6	-
P value (Paired t)		0.002*	0.021**	0.349	-
Size effect		0.789	0.612	-	

MCE: Motor control exercises
*Significant intergroup differences, **Significant intragroup differences, Data are reported as mean ± SD.

Table 4. Data on the postural sway of the subjects

Variable	Test	MCE + Suspension exercises	MCE	Control group	P value (Covariance)
Sway range, eyes-open	Pre-test Post-test	58.60 ± 8.11 41.70 ± 6.44	55.7 ± 8.48 44.60 ± 8.57	59.30 ± 11.26 61.60 ± 8.41	0.368 0.006*
	Intragroup changes (%)	29	19	3	-
P value (Paired t)		0.001**	0.017**	0.371	-
Size effect		0.789	0.611	-	
Sway area, eyes-open	Pre-test Post-test	310.37 ± 43.40 260.54 ± 63.60	321.44 ± 32.60 272.64 ± 47.40	316.28 ± 21.30 321.61 ± 27.80	0.417 0.005*
	Intragroup changes (%)	16	15	1	-
P value (Paired t)		0.001**	0.014**	0.439	-
Size effect		0.739	0.695	-	
Sway range, eyes-closed	Pre-test Post-test	77.20 ± 6.44 52.50 ± 7.59	79.60 ± 8.67 58.60 ± 5.45	81.30 ± 5.53 82.90 ± 9.57	0.317 0.003*
	Intragroup changes (%)	32	26	1.22	-
P value (Paired t)		0.003**	0.010**	0.239	-
Size effect		0.607	0.503	-	
Sway area, eyes-closed	Pre-test Post-test	379.55 ± 36.30 326.65 ± 39.40	375.76 ± 38.50 341.54 ± 26.30	360.00 ± 63.40 366.43 ± 45.70	0.457 0.005*
	Intragroup changes (%)	13	9	1.63	
P value (Paired t)		0.001**	0.020**	0.378	-
Size effect		0.507	0.414	-	

MCE: Motor control exercises
*Significant intergroup differences, **Significant intragroup differences, Data are reported as mean ± SD.

The subjects in the combined exercise group (MCE + high-threshold suspension exercises) reported a greater decrease in the pain variable compared to the participants in the low-threshold movement control group. Previous studies have suggested that patients with LBP experience delayed activation of deep muscles in the trunk area to perform dynamic movements, as well as controlling the spine (25). Additionally, patients with LBP tend to have increased stiffness in the spine so that they can compensate for the deep muscle disorders by activating the superficial muscles. In addition to reducing pain, MCE can reduce other symptoms of LBP by correcting and coordinating muscle movement and spinal control (25). The positive effect of MCEs and TRX on reducing pain and disability and increasing patients' sensory accuracy has been proven (26). The findings of some studies indicate that (low-threshold) MCEs can be more useful in movement control and endurance variables in comparison to the (high-threshold) deadlift exercises, while in the pain variable, no difference was observed between the two interventions (18). One of the reasons for the reduction in pain in the present study after eight weeks of separate and combined exercises may be the active control of improper formation of pain-causing factors in the lumbar spine and removing the person from the defective process of pain.

The results of the present study were similar to the findings of some studies (27,28). Previous studies have shown that patients with LBP have delays and problems in activating the deep muscles of the spine, making it difficult to control the trunk muscles (25). MCEs improve the control, coordination, and timely activation of these muscles (26). In a study, Shamsi et al. concluded that MCEs and general exercises had a positive effect on improving the performance of lumbo-pelvic endurance tests and reducing pain and disability (29). Furthermore, some studies have concluded that TRX with the aim of increasing strength and endurance is a good alternative to traditional exercises (30-32). On the other hand, suspension exercises can increase the activity of the trunk muscles and muscle cocontraction (31) and, on average, lead to a 22% increase in the performance of individuals (31,32).

Many daily and sports activities are performed in dynamic and relatively unstable conditions. One of the advantages of the suspension exercises is to transfer energy in an optimal way and the daily activities are enhanced based on the needs, thus increasing individuals' performance (31). Therefore, performance enhancement can be expected with reduced pain and disability (32). Given that high-threshold MCE and TRX exercises take into account all of the above-mentioned indicators, performance improvement by performing these exercises seems logical.

The decreased postural sway index of the participants in this study after eight weeks of treatment intervention is associated with different causes. Postural control disorder in subjects with chronic LBP can be due to changes in proprioceptive feedback due to defects in the proprioceptive system and, consequently, reduced accuracy of the proprioceptive information in the lumbar spine (33). Overall, experts have confirmed the presence of lumbo-pelvic proprioceptive impairment in people with chronic LBP (28,33). On the other hand, information from lumbo-pelvic proprioceptive receptors plays a key role in the production and initiation of posture control responses, and posture control impairment can be expected in individuals with chronic LBP due to the functional disorders in the stabilizing muscles of this area that are the main origin of the proprioceptive data (33).

One of the possible causes of the postural control disorder is the proprioceptive impairment. Awareness of movement is an important sense to control movement and coordinate the trunk muscles during the movement (28). In addition, paraspinal muscle dysfunction can also be another possible cause of the postural control disorders (27). Physiologically, pain messages in people with LBP increase the sensitivity of the mechanical receptors, and hence, accurate messages are not transmitted to the central nervous system (CNS) (27,28). Possible causes of the combined exercises in postural control and subsequent reduction of postural sway in subjects with chronic non-specific LBP in the standing position in the eyes-open and -closed states can be attributed to the improvements in the proprioceptive system, improved sense of trunk muscle movement, improved performance of the paraspinal muscle spindles, the ability to use the hip strategy, the reduced effect of muscle fatigue due to the increased natural lumbar muscle activity, and delay in muscle activation in individuals with non-specific chronic LBP (27,28,34). It seems that a more significant improvement in the proprioceptive system after eight weeks of combined exercises is the most prominent and important factor in improving the postural sway of the subjects with non-specific chronic LBP.

Limitations

Muscle electromyography (EMG) and the effect of persistence of exercise were not investigated in the present study.

Recommendations

In future studies, it is suggested that the electromyographic activity of the erector spinae muscles and TVA muscles be examined.

Conclusion

Based on the results of the present study, it can be concluded that creating stability in the trunk area or effectively using the muscles around the trunk and pelvis, has a great impact on the production and transmission of forces through the spine, as well as controlling the lower back and back muscles and pelvic muscles to maintain the trunk stability. Moreover, in the suspension exercises, the person is trained to optimally transfer the force among different parts of the body and the daily activities are enhanced based on the needs, leading to the reduced postural sway (creating better stability), reduced pain, and enhanced function.

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Authors' Contribution

Gelareh Alamooti: Study design and ideation, supportive, executive, and scientific services of the study, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript arrangement, specialized manuscript evaluation in scientific concepts, final manuscript approval to submit to the journal office, responsibility of maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments; Amir Letafatkar: Study design and ideation, supportive, executive, and scientific services of the study, analysis and interpretation of results, specialized statistical services, manuscript arrangement, specialized manuscript evaluation in scientific concepts, final manuscript approval to submit to the journal office, responsibility of maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments; Seyed Sadredin Shojaedin: supportive, executive, and scientific services of the study, analysis and interpretation of results, specialized statistical services, manuscript arrangement, specialized manuscript evaluation in scientific concepts, final manuscript approval to submit to the journal office, responsibility of maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments; Reza Alizadeh: supportive, executive, and scientific services of the study, manuscript arrangement, specialized manuscript evaluation in scientific concepts, final manuscript approval to submit to the journal office, responsibility of maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest.

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Appendix 1. Motor control exercise (MCE) program

The exercises were performed in 16 sessions (eight weeks and two sessions per week) and individually. Each exercise was designed according to a pattern of movement causing pain for the person. The exercises were chosen exclusively with the goal to restore the individuals' natural movements. The exercises were performed in three stages, and each person advanced to the next stage if the first stage was completed and the pain was reduced.

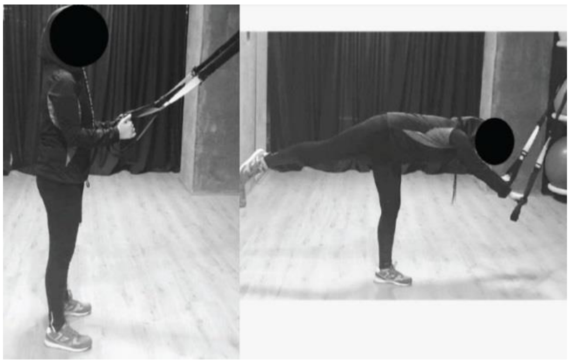
First stage: At this stage, the movements were designed in the same way for different subjects. The exercises were performed twice a week each for 20 to 30 minutes, and the subjects performed the movements three times a day with at least 10 repetitions in two sets at home. At this stage, the subjects were taught to maintain the normal lumbopelvic joint position while lying on the chest, lying on the abdomen, standing position, sitting position, and on all fours position, and by moving their arms and legs, maintain the normal position of the joint and increase time and repetition by improving movement. The purpose of the first stage of the exercise was to maintain the normal position of the joint and the direction of the spine in the movements of the upper and lower limbs, pelvis, and shoulders.

Second stage: The most painful positions were identified for each subject and different exercises were given in the same positions according to the movement patterns that caused pain in the lumbar region.

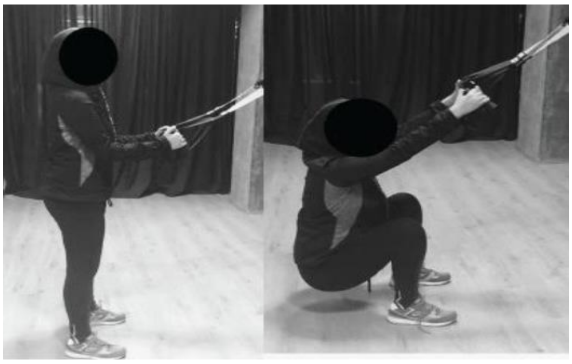
The goal of this step was to reduce the high effort to do the movements, reduce stiffness, strengthen the stabilizing muscles, and control movement in the desired range of the joint.

Third stage: At this stage, the individuals had to be able to maintain the normal position of the spine and the lumbopelvic joint in the dynamic movements, and perform the correct movement pattern that they used a lot during the day. For example, the subjects learned to keep the spine in a normal position to perform the forward bending movement, and first use the knee joint flexion to bend forward, in addition to preventing the flexion of this section using the stabilizers of the muscles supporting the spine.

Appendix 2. Suspension exercise program



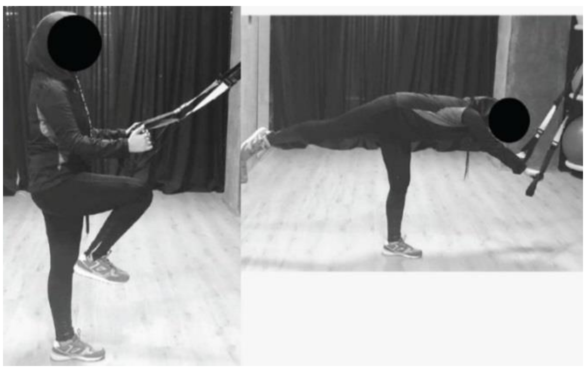
Romanian deadlift



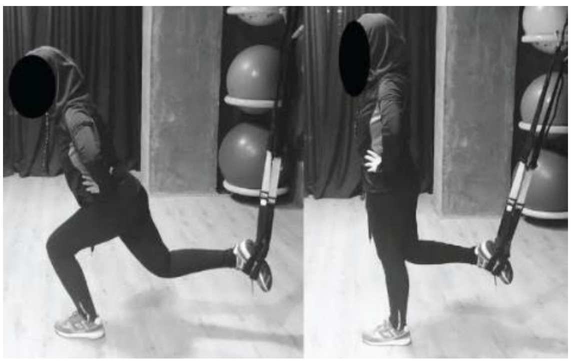
Deep squat

Figure four stretch

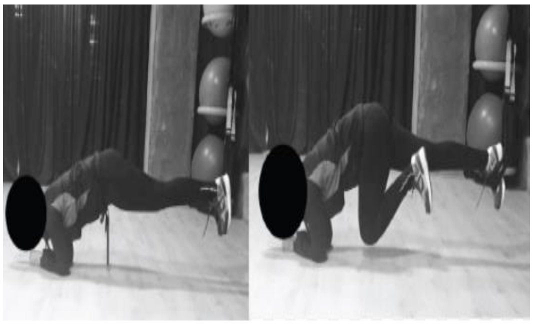
90 degree low row



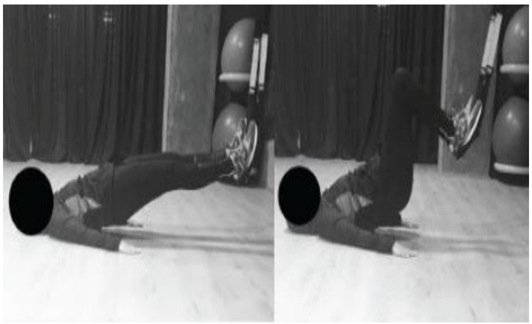
Single-leg reaching Romanian deadlift



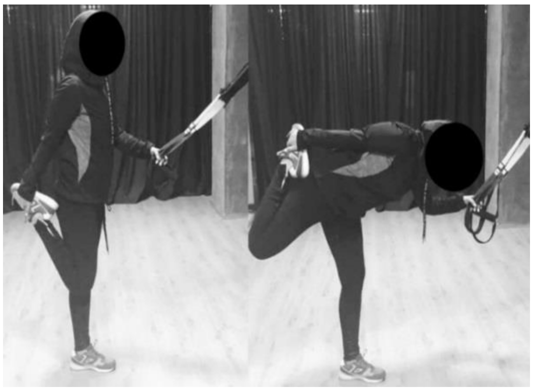
Reverse lunge



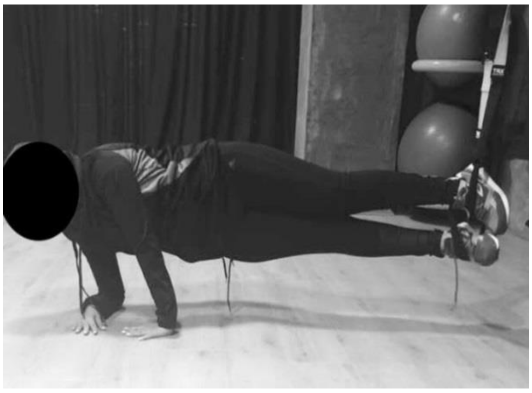
Sprinter plank



Lying leg curl



Reaching hip flexor stretch



Side plank