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Effect of different exercise programs on non-specific chronic low back pain and disability in people who perform sedentary work

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ABSTRACT

Background: This study compared the short- and long-term effects of different exercise programs on lumbar muscle function, cross-sectional area of the multifidus muscle, functional disability and low back pain in people who perform sedentary work.

Methods: A total of 70 volunteer women with sedentary occupations suffering from low back pain were randomized to either the lumbar stabilization exercise program group or the lumbar muscle strengthening exercise program group. All subjects entered the 20-week exercise programs. The measurement of the cross-sectional area of the multifidus muscle was executed by using an ultrasound system, isokinetic peak torque was measured applying an isokinetic dynamometer.

Findings: The results indicated that the 20-week exercise programs reduced low back pain and functional disability. Positive effects for the cross-sectional area of the multifidus muscle, functional disability and low back pain lasted for 4 weeks after the application of lumbar muscle strengthening exercise program and for 12 weeks after the application of lumbar stabilization exercise program. The lumbar muscle strength increased and lasted for 8 weeks after both exercise programs.

Interpretation: The 20-week lumbar stabilization exercise and muscle strengthening exercise programs were efficacious in decreasing LBP and functional disability in people performing sedentary work, however the lumbar stabilization exercise program was more effective, and this effect lasted for 12 weeks after completion of the program.

1. Introduction

Non-specific chronic low back pain (LBP) is a rather common and predominant health problem worldwide that affects people of all ages (Maher et al., 2016; Park et al., 2018; Yang et al., 2017). > 80% of working-age people experience LBP at least once in their lives (Vujcic et al., 2018). Research has highlighted the increased prevalence of LBP among young and middle-aged people (Hoy et al., 2014).

In cases of LBP, reduced spinal segment mobility, decreased activity and stamina of the deep trunk muscles (especially multiple and transverse abdominal, obliquus internus), and decreased multifidus muscle cross sectional area (CSA) are detected (Casser et al., 2016; Hides et al., 2008b).

A sedentary lifestyle with a lack of physical activity results in the loss of muscle power and strength and can be a predictor of LBP leading to recurrent LBP (Citko et al., 2018). Continuous pressure on the intervertebral disc and decreased metabolic exchange and disc nutrition weakened posterior lumbar structures (Corlett, 2006; Kingma et al., 2000). One of the risk factors of LBP is weakness of the superficial and deep trunk and abdominal muscles, therefore strengthening these muscles significantly reduces functional disability and pain (Danneels et al., 2001; Hayden et al., 2010; Hodges et al., 2003).

Individuals with LBP are recommended physiotherapy. The causes of LBP are varied with different exercise programs used to treat patients including aerobic exercise, muscle building, flexibility and stretching exercises (Gomes-Neto et al., 2017; Hayden et al., 2010; Lawand et al., 2015; Saragiotto et al., 2016).

Most often they are prescribed a traditional muscle-strengthening program that strengthens large superficial back and abdominal muscles. The shortcoming of such a program is the inability to target deep back muscles and inappropriate waist stabilization (Cornwall et al., 2006; Kumar, 2011). Stability of lumbar spine segments is an important component of the body biomechanics, and the lack of stability can affect the occurrence of LBP (Kumar, 2011). Currently there is a popular

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exercise program that uses spinal stabilization exercises to train deep pelvic floor muscles as well as back and transverse muscles (Gordon and Bloxham, 2016; Ko et al., 2018; Kumar, 2011).

However, it remains unclear which exercise program has a greater effect and a longer lasting positive effect on people suffering from LBP and performing sedentary work.

The aim of this study was to assess the immediate effect and the lasting effect of different exercise programs on lumbar muscle function, cross-sectional area of the multifidus muscle, functional disability and LBP in people performing sedentary work.

2. Methods

Seventy female volunteers suffering non-specific LBP were randomized to either the lumbar stabilization exercise program group ($n = 35$) or the lumbar muscle strengthening exercise program group (n = 35). All subjects had been suffering from LBP for at least 12 weeks. The study did not include patients with neurological symptoms, spinal damage, cancer or infectious diseases that could lead to LBP or any other diseases that could affect physical performance. Patients with myoparalysis, paraesthesia and psychological problems in addition to patients who had trouble in performing exercise because of difficulties to understand were also excluded. None of the study participants had undergone surgery for LBP. For 8 h/day participants performed sedentary work, and their lifestyle was sedentary as well. The mean age of the lumbar stabilization exercise group subjects was 38.3 years (SD 5.1 years), their body weight was 65.1 kg (SD 7.9 kg), height 168.3 cm (SD 3.7 cm). The lumbar muscle strengthening exercise group comprised women aged 38.5 years (SD 6.2 years), with a body weight of 66.3 kg (SD 8.2 kg), and a height of 167.8 cm (SD 4.7 cm). The lumbar stabilization exercise group subjects were enrolled in a 20-week exercise program to increase lumbar stability. The lumbar muscle strengthening exercise group subjects were enrolled in a 20-week exercise program to increase lumbar muscle strength. None of the women had previously been involved in similar studies. All subjects were asked not to use any medication, such as muscle relaxants, analgesics, or psychotropic drugs, for at least 4 days before testing.

This study was approved by the Kaunas Regional Ethics Committee of Biomedical Research (Protocol No BE-10-15). Each volunteer read and signed the informed consent form before participation in the study.

Before starting the exercise program, after completing it and at 4, 8 and 12 weeks after the intervention, the following tests were carried out: isokinetic peak torque at an angular velocity of 60°/s, measured using a Biodex System 3 Pro isokinetic dynamometer; measurement of the cross-sectional area of the multifidus muscle, performed using a TITAN™ ultrasound system, and assessment using the Oswestry disability index (ODI), as well as visual analogue (VAS) rating scales.

The exercise program was performed twice a week; the time period of each session was 45 min. The exercise program endured for 20 weeks, therefore patients participated in a total of 40 exercise sessions. The subjects performed exercises under the supervision of a rehabilitation doctor and a physical therapist. The physical therapist helped each subject to achieve the right exercise position. The programs were divided into three categories: warm up, main part and cool down. Both warm up and cool down static and dynamic stretching exercises were performed easy and without pain with amplitude of motion and lasted for 5 min.

The lumbar stabilization exercise program consisted of the selected exercises which were used to strengthen the deep trunk stabilizing muscles (especially transverse abdominal, internal oblique and lumbar multifidus) and control pelvic muscles (Fig. 1). The participants needed to perform from 8 to 16 repetitions of all exercises, except *Hundred* (100 repetitions), (Fig. 1). The lumbar stabilization exercise group subjects' lumbar neutral spine position was controlled by the physiotherapist at the beginning of each exercise, and the subjects were asked to sustain this position all through the exercise. An identical order was applied to the exercises. The exercises met suggested criteria for safety; these included the avoidance of active hip flexion with fixed foot positioning and pulling with the hands behind the head and ensuring knee and hip flexion during all upper body exercises. Participants of the lumbar muscle strengthening exercise program group performed the selected exercises which were used to improve trunk flexor (rectus abdominis) and extensor (erector spinae) muscles strength. The participants needed to perform from 8 to 16 repetitions of all exercises (Fig. 2).

The subjects were tested using a Biodex Medical System PRO 3 dynamometer (certified ISO 9001 EN 46001; Shirley, NY, USA). Isokinetic peak torque was measured at an angular velocity of 60°/s (Kliziene et al., 2016; Sekendiz et al., 2007). Mechanical brakes were applied at 60° of amplitude in order to minimize unwanted movements (Den Hartog et al., 2010). Prior to testing, all subjects were familiarized with the methodology of the assessment and then performed a standard warm-up which involved exercising on the ergometer (Ergo-Fit Ergo Cycle 177, Pirmasens, Germany) at low intensity for 5 min (heart rate 110–130 beats/min). After warming up, the subjects sat in the Biodex System 3 PRO chair and remained quiet for 2 min. Shoulder, torso and thigh straps were used to maintain the angle between the waist and thigh at 90° (Kliziene et al., 2016). During the test the subjects were asked to minimize head movements and keep hands crossed on the chest. After several practice movements followed by 5 min rest, volunteers performed maximal isokinetic voluntary trunk flexion involving three trunk flexion and extension movements using maximal effort. For data analysis we used the value indicating the highest maximal force.

Ultrasound scanning of the muscles was carried out using a TITAN™ ultrasound system (SonoSite Inc., Bothell, WA, USA). Multifidus muscle CSAs (cm^2) was measured in the B-scan mode. The surfaces of the muscles, organs and blood vessels were imaged by the HST/10–5 MHz 25 mm linear probe at a frequency of 10 MHz. The patients were located face down in a neutral and relaxed head position, with their arms resting at their sides. Lordosis of the lumbar spine was reduced by placing a small pillow under the abdomen. The ultrasound scanning of multifidus muscles was applied in parallel on both sides of the spine in the L4–L5 region. The process of palpation was used to identify the fourth lumbar vertebra (L4) starting from the wings of the hip bones towards the centre line (Kliziene et al., 2015). Where the view of ultrasound image was brightest, the CSA of multifidus was measured by tracing around the inner edge of the muscle boundaries. The CSA (cm^2) of lumbar multifidus muscle was measured according to method of Hides et al. (1992).

An ODI questionnaire was used to rate the effects of LBP intensity on the patient's functional state in different life situations. Pain intensity was rated by applying a visual analogue pain scale (VAS) with a range of 0 to 10 points, where 0 = no pain; 2 = mild pain; 4 = moderate pain; 6 = severe pain; 8 = very severe pain; and 10 = unbearable pain.

2.1. Statistical analysis

The Shapiro-Wilk test was used to test all data for normal distribution, and all data were observed to be normally distributed. A two-way mixed analysis ANOVA (general linear model) was used to regulate the effect of the exercise program as within subject factor of two levels, within group (results before exercise program were compared with results immediately after exercise program and after 4, 8 and 12 weeks post exercise program) and between groups (lumbar stabilization exercise group and lumbar muscle strengthening exercise group) at the same time intervals. Pearson's correlation coefficients were determined by correlation analyzes after exercise program at the same time intervals between LBP and the maximum isometric trunk flexion strength, CSA and ODI. Strong correlation 0.7–1.0, good correlation 0.5–0.7, moderate correlation 0.5–0.3 and poor correlation < 0.3 (Hazra and Gogtay, 2016). The level of significance was set at $P < 0.05$. All statistical analyses were performed using IBM SPSS Statistics ver. 22 (IBM

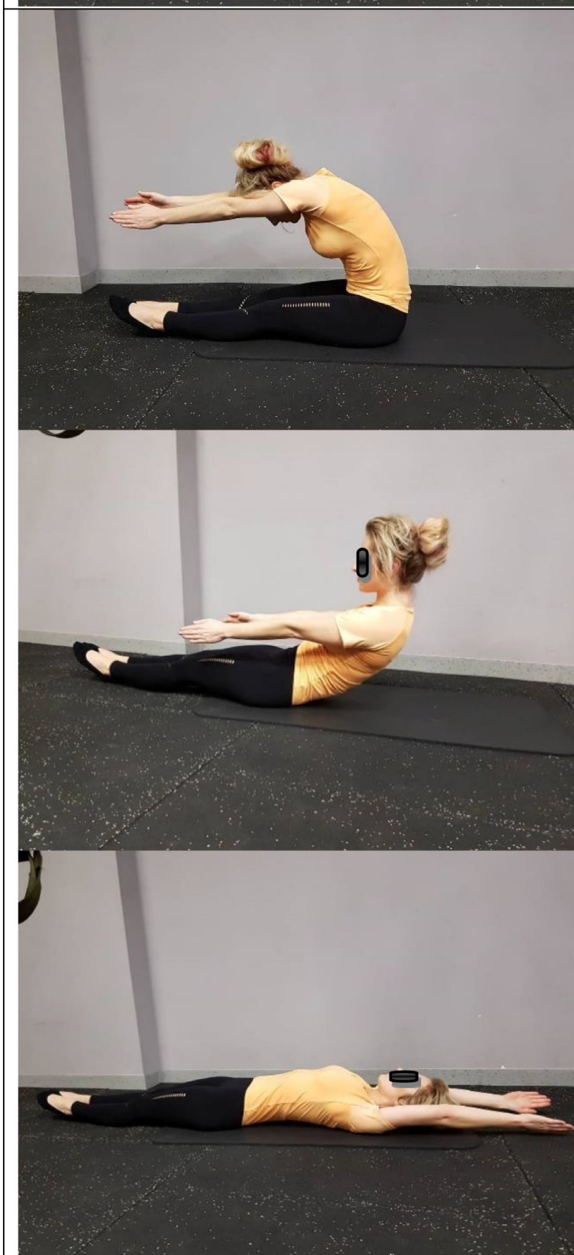
	**Spine curl.** The starting position had to be a relaxed position with neutral pelvis and spine. Subjects had to breath in, breath out and curl the pelvis from the mat sequentially up from the mat vertebra by vertebra rolling the spine. Then the spine had to be rolled back to the neutral position.
	**Roll down.** Subjects had to lie down, stretch arms above head and lower shoulders. Subjects breathed in, activating pelvic muscles and breathed out, stretching arms forward. While tensing bottom muscles with raised head and lifting up from the carpet with rounded back, raising one vertebra at a time.

Fig. 1. Lumbar stabilization exercise program
Note: The sequence of exercises: Spine curl; Roll down; Curl up; Rolling like a ball; Hundred; Cat; Side balance; Side band with rotation.

	**Curl up.** Neutral spine and pelvis was kept as starting position for subjects. Inhalation was done while exhaling curl spine, keeping head in the palms and space between chin and chest, legs in one line with hips, or in frog position. Inhalation was done while lying down to the starting position.
	**Rolling like a ball**. In a seated position, shins had to be hugged into chest and sacrum balanced in order to lift feet off the mat. Subject's body had to be held in a ball shape and knees remain shoulder distance apart with the ankles close together. Inhalation was done as rolling back to shoulder blades. Exhalation was done as rolling up to the start position, maintaining the curve of the spine. The C-curve shape of spine had to be maintained. Head and neck had not to touch the mat while rolling back.
	**Hundred.** Subjects had to lie down on the mat with legs pressed together. While exhaling, head, shoulders and arms had to be lifted up and both legs raised off the mat to the desired height. Arms had to be pumped for 100 times. Inhalation and exhalation was done for five arm pumps. The abdominals had to be kept drawn into the mat and back remain flat on the mat.
	**Cat.** The starting position for subjects was four-point kneeling, while breathing in and breathing out. Subjects had to roll the pelvic underneath, flex and round the lower back and continue this flexion to allow upper back to round gradually followed by the neck.

Fig. 1. (*continued*)

	**Side balance.** Subjects had to lie on the right side and correctly align pelvis and spine, keeping head, neck and legs in line with spine, connecting inner tights in parallel with softly pointed feet. Subjects had to inhale, exhale, lift both legs from the mat to the level with the top of the pelvis and maintain a stable and still pelvis and spine for 10-20 sec. It was repeated to the other side.
 	**Side band with rotation.** The starting position was on the left side with hip, knee and elbow in a line, keeping both legs together with inner tights connected. Subjects had to breathe in and maintain a neutral pelvic and open top knee and arm, keeping feet connected together. When breathing out, subjects had to rotate the spine to the mat, simultaneously reaching with left arm the floor under the right side. It was repeated to the other side.

Fig. 1. (*continued*)

Corporation, Armonk, NY, USA).

3. Results

After finishing the 20-week exercise programs, the LBP and ODI scores decreased, maximal isokinetic trunk extension and flexion peak torque and multifidus muscle CSA values were significantly higher in both groups. The data showed significant differences compared with results before exercise program (baseline) and results immediately after exercise program and after 4, 8 and 12 weeks post exercise program. Significant changes were found between the lumbar stabilization exercise program and the lumbar muscle strengthening exercise program (Tables 1, 2 and 3).

After the completion of exercise programs, LBP significantly correlated with the maximum isometric trunk flexion strength, CSA and ODI (Table 4).

4. Discussion

In this study we established that after participating in a 20-week exercise program, LBP and functional disability decreased in persons with LBP.

Many researchers have worked hard to find an appropriate special exercise program that will significantly reduce pain and increase functional capacity for people with LBP (Kim et al., 2018; Yang et al., 2017). Only a few studies have directly compared a stabilization exercise program with other exercise programs. Our study compared a lumbar stabilization exercise program with a muscle strength program for patients with LBP. The lasting effect of the lumbar stabilization exercise program was more pronounced and lasting than the effect of the strength exercise program. The positive effect (LBP, CSA) of the lumbar stabilization exercise program persisted for 12 weeks. With the aim of comparing our results with those of other researchers we reviewed many of the studies dealing with this issue and found a variety

	**Sit-up.** Subjects had to lie with their back on the floor, with hands behind the head and the knees bent. Then they curled upper body toward their knees and lowered down returning to starting position
 	**Sit-up with both legs up**. In a supine position on the floor with hands behind the head, knees flexed at 90 deg, and feet flat on the floor, the subjects were instructed to raise the upper torso up to a 45 deg without the curling-up movement. Subjects had to lift the upper body and legs, changing legs and sides.
	**Sit-up with changing legs and sides.** In a supine position on the floor with hands behind the head, knees flexed at 90 deg, the subjects were instructed to raise the upper torso up to a 45 deg without the curling-up movement. Subjects had to lift the upper body and legs, changing legs and sides.

Fig. 2. Trunk muscle-strengthening exercise program
Note: The sequence of exercises: Sit-up; Sit-up with both legs up; Sit-up with changing legs and sides; Sit-up with legs up; Cross sit-up; Side plank clam; Prone plank; Push up.

 	**Sit-up with legs up.** In a supine position on the floor with hands behind the head, knees flexed at 90 deg, and feet flat on the floor, the subjects were instructed to raise the upper torso up to a 45 deg without the curling-up movement. Subjects had to lift the upper body and legs up.
	**Cross sit-up.** Subjects had to lie on the floor with knees flexed at 90 deg. Bent left leg lifted on right knee, with hands behind the head and elbows opened wide. Then curled upper body toward left knee. Right elbow had to touch left knee. Then lowered down returning to starting position, changing legs and sides.
	**Side plank clam**. Subjects had to set up on side propped up on forearm with elbow underneath shoulder. Knees had to be bended so that feet and lower legs were behind. Then bottom hip had to be lifted up off the ground, driving through knee and forearm. Top leg had to be lifted up and toward the ceiling, keeping the knee bent. Subjects had to keep legs open, lifting top knee toward the ceiling.

Fig. 2. (*continued*)

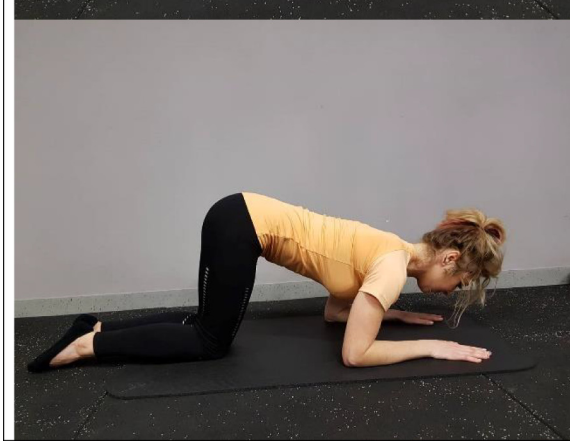
	
	**Prone plank**. In a prone position on the floor with the elbow angle at 90 deg (180 = full extension) and the forearms placed underneath the chest, pelvis raised off the floor and body weight distributed on the forearms and toes, the subjects were instructed to maintain a flat position.
 	**Push up.** Subjects had to get into a push-up position, supporting body on hands. Exhalation was done as subjects extended their elbows and pushed bodies back up to the starting position.

Fig. 2. (*continued*)

Table 1
Values of maximal isokinetic trunk extension and flexion peak torque (Nm).

	Extension		Flexion	
	Stabilization group	Strengthening group	Stabilization group	Strengthening group
Baseline	133.1 (SD 9.6)	132.1 (SD 7.4)	91.7 (SD 8.3)	89.9 (SD 9.1)
Post intervention exercise program	214.1 (SD 7.3)*,#	239.3 (SD 7.7)*	122.6 (SD 9.2)*,#	147.9 (SD 8.5)*
4 weeks post exercise program	199.8 (SD 6.1)*,#	219.9 (SD 7.2)*	111.3 (SD 4.7)*,#	134.8 (SD 9.8)*
8 weeks post exercise program	174.4 (SD 8.3)*	179.5 (SD 7.1)*	104.1 (SD 9.2)*	115.3 (SD 6.3)*
12 weeks post exercise program	147.2 (SD 8.1)	142.3 (SD 9.2)	98.1 (SD 7.6)	99.6 (SD 5.5)

* Data before exercise program (baseline) for each group was compared separately with data of post intervention and data after 4, 8 and 12 weeks post exercise program, $P < 0.001$.

\# Data before exercise program (baseline), post intervention data and data after 4, 8 and 12 weeks post exercise program, was compared between groups, $P < 0.05$).

of results. In previous studies the duration was different, for example involving a lumbar stabilization exercise program lasting 4, 6, 10, 12, 16 or 20 weeks, and this could have influenced the results (Cho et al., 2014; Goldby et al., 2006; Kliziene et al., 2015; Kliziene et al., 2016; Smith et al., 2011; Stuge et al., 2004). The results reported by other researchers showed that a 20-week stabilization exercise program was more effective in reducing the level of LBP and disability than an exercise program without stabilization exercises, and this positive effect was maintained even after a year's break (Stuge et al., 2004). The results of previous studies have shown that 24 weeks after finishing a program of spinal stabilization exercises, LBP recurred in 30% of subjects, while in the control group who underwent a conventional physiotherapy program, LBP returned in 84% of patients (Hides et al., 2008a; Hides et al., 2008b). Thus, the effects of stabilization exercises persist longer than those of manual therapy or healthy behaviour learning, but in some patients, pain returns once the patient stops performing the exercises (Goldby et al., 2006).

Our study involved women who had sedentary jobs and were not previously engaged in sports activities. Research shows that employees who spend most of their working time being sedentary suffer from LBP (Korshøj et al., 2018; Lunde et al., 2017). In the sitting position, the muscles of the whole body are not very active, so long periods sitting and reduced muscle activity leads to an increased load on the intervertebral discs, which leads to a change in the natural spine curvature and weakening of the paravertebral muscles attached to the vertebrae, resulting in degenerative spinal processes (Yamauchi et al., 2015). For people with low physical activity levels, muscle function is weakened, i.e. muscle deconditioning occurs (Steele et al., 2014). Complex loads affect passive spinal ligament structures and in case of inadequate spine protection, lumbar spine damage increases (Stevens et al., 2007). In cases of LBP, specific acute or chronic processes take place in the trunk muscles that reduce muscle CSA (Fortin and Macedo, 2013). This is a localized specific muscle response to reduced muscle activity. After prolonged physical inactivity, paraspinal muscle atrophy occurs and the CSA of the multifidus muscles decreases (Fortin and Macedo, 2013; Hides et al., 2008a; Kamaz et al., 2007). Paraspinal muscle atrophy is significant in predicting long-term LBP (Fortin et al., 2015). For persons with LBP, the highest CSA decrease occurs in the multifidus and paraspinal muscles (Goubert et al., 2016).

In persons with LBP, weakened trunk muscles are seen when measuring isometric or isokinetic contraction and their lumbar extensor muscle endurance is also decreased (Cho et al., 2014). The result of muscle strength and stamina decrease is muscle atrophy. Thus, muscular atrophy requires the use of therapy and we applied physical exercises. After 20 weeks of physical exercise, we established a significant increase in lumbar muscle strength that lasted for 12 weeks after the program completion. The intensity of LBP in subjects significantly correlated with maximal isokinetic trunk flexion strength immediately after the exercise program and 4 weeks after the intervention. It is possible that the initial results of lumbar muscle strength were influenced by the LBP felt by subjects. Therefore, motor control might be significantly different because the activity of the agonist muscles decreases while that of the antagonist muscles increases thus reducing the speed, strength and amplitude of movements when pain occurs (Hodges, 2001).

Our research results showed that CSA increased after 20 weeks of both exercise programs. However, after spinal stabilization exercises a significant increase was shown in CSA and this positive effect lasted for 12 weeks after the end of the exercise program. Previous studies have shown that after 10 weeks of stabilization training with dynamic static resistance exercise, lumbar multifidus muscle CSA increased in persons with cLBP (Danneels et al., 2001). Spinal stabilization exercises have a statistically significant effect on LBP reduction, and a statistically-significant increase in cross-sectional area was obtained by estimating the lumbar muscle cross-sectional area at L5 level (Hides et al., 2008a). Other studies have shown that an 8-week spinal stabilization exercise program reduces lumbar muscle atrophy, reduces pain, disability levels, and increases trunk muscle strength in LBP patients (Kalichman et al.,

Table 2
Values of cross-sectional area (cm^2) of the lumbar multifidus muscles.

	Right side		Left side	
	Stabilization group	Strengthening group	Stabilization group	Strengthening group
Baseline	5.0 (SD 0.7)	5.1 (SD 0.3)	4.9 (SD 0.9)	5.0 (SD 0.4)
Post intervention exercise program	8.1 (SD 0.3)*,#	5.6 (SD 0.9)**	8.2 (SD 0.2)*,#	5.7 (SD) 0.6**
4 weeks post exercise program	7.6 (SD 0.7)*,#	5.4 (SD 0.6)**	7.7 (SD 0.5)*,#	5.4 (SD 0.3)**
8 weeks post exercise program	7.2 (SD 0.3)*,#	5.2 (SD 0.7)	7.3 (SD 0.4)*,#	5.2 (SD 0.9)
12 weeks post exercise program	6.1 (SD 0.5)*,#	5.1 (SD 0.9)	6.4 (SD 0.6)*,#	5.1 (SD 0.9)

* Data before exercise program (baseline) for each group was compared separately with data of post intervention and data after 4, 8 and 12 weeks post exercise program, $P < 0.001$.

** $P < 0.05$.

\# Data before exercise program (baseline), post intervention data and data after 4, 8 and 12 weeks post exercise program, was compared between groups, $P < 0.05$).

Table 3
Oswestry disability index and low back pain intensity (scores).

	Oswestry disability index		Low back pain	
	Stabilization group	Strengthening group	Stabilization group	Strengthening group
Baseline	22.3 (SD 07)	21.6 (SD 0.3)	5.5 (SD 0.3)	5.4 (SD 0.2)
Post intervention exercise program	7.8 (SD 0.3)*,#	9.4 (SD 0.9)*	1.3 (SD 0.02)*,#	1.4 (SD 0.03)*
4 weeks post exercise program	8.6 (SD 0.7)*,#	11.2 (SD 0.6)*	1.7 (SD 0.05)*,#	2.6 (SD 0.06)*
8 weeks post exercise program	9.5 (SD 0.3)*,#	16.3 (SD 0.7)	3.4 (SD 0.2)*,#	5.1 (SD 0.8)
12 weeks post exercise program	11.4 (SD 0.5)*,#	17.6 (SD 0.9)	4.2 (SD 0.1)*,#	5.3 (SD 0.7)

* Data before exercise program (baseline) for each group was compared separately with data of post intervention and data after 4, 8 and 12 weeks post exercise program, $P < 0.05$.
# Data before exercise program (baseline), post intervention data and data after 4, 8 and 12 weeks post exercise program, was compared between groups, $P < 0.05$).

2017). However, other researchers believe that there is a lack of evidence of a causal relationship between changes in strength or CSA and pain, disability, and specific treatment for LBP (Valdivieso et al., 2018). It has been observed that the relationship between pain and muscle strength is evident when weaker paraspinal muscles do not protect the spine and pelvic structure from excessive load and damage in daily movements or sports activities (Valdivieso et al., 2018). In individuals with LBP, the spinal stabilization function of the deep trunk muscles, inter-muscular coordination, nerve control and the accuracy of proprioceptive information are reduced (Hides et al., 2008a).

LBP associated with musculoskeletal disorders is reduced by treatments that affect muscle strength and endurance (Steele and Bruce-Low, 2012). Lumbar spinal stability is one of the most important goals of LBP treatment (Grenier and McGill, 2007). For individuals with LBP who performed spinal stabilization exercises which restored the function of the deep trunk muscles, back pain was less frequent afterwards than in those who did not receive therapy involving these exercises (Hides et al., 2011). Traditional exercise programs used for the treatment of LBP include strengthening and stretching the large superficial back and abdominal muscles, but they do not include stabilization exercises. The disadvantage of such programs is the inability to activate the deepest back muscle layers as well as inappropriate pelvic immobilization, which can cause injury during exercise (Cairns et al., 2006; McGill et al., 2003).

We also observed a relationship between LBP and ODI, so we can assume that it is possible to significantly reduce functional disability while attempting to ameliorate LBP. When individuals who suffer from LBP have control over their trunk muscles performing functional tasks, this reduces daily activity limitations and improves their overall well-being (Hides et al., 2011).

Exercises that focus on deep stabilizing muscles as well as stretching and relaxation exercises form an effective and safe rehabilitation tool that reduces the patient's LBP (Tomanova et al., 2015). After reviewing many other research publications, we believe that this issue has not been resolved and further research is needed. An overview of our research data suggests that regular lumbar stabilization exercise programs improve trunk stability and mobility, strengthen trunk muscles, decrease LBP, and improve lumbar spine functionality. Both exercise programs, lumbar stabilization exercise and muscle strengthening exercise, decreased LBP and functional disability and increased lumbar muscle strength. However, the lumbar stabilization exercise program was more effective and its positive effects were more lasting for persons with LBP and who performing sedentary work. We established that reduced LBP and functional disability as well as increased multifidus muscle CSA persist for 12 weeks, while the increased trunk muscle peak torque remains 8 weeks after completion of the lumbar stabilization exercise program which lasted for 20 weeks.

The limitation of this study is its short duration, as the long-term effects of a lumbar stabilization exercise program in persons with LBP remain unknown after 24 weeks of suspended exercises.

5. Conclusion

The 20-week lumbar stabilization exercise and muscle strengthening exercise programs were efficacious in decreasing LBP and functional disability in people performing sedentary work, however the lumbar stabilization exercise program was more effective, and this effect lasted for 12 weeks after completion of the program.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

Table 4
Correlation relationship between low back pain intensity and the cross-sectional area of the lumbar multifidus muscles, Oswestry disability index and maximal isokinetic trunk flexion peak torque.

	Cross-sectional area		Oswestry disability index		Isokinetic flexion peak torque	
	Stabilization group	Strengthening group	Stabilization group	Strengthening group	Stabilization group	Strengthening group
Pain post intervention exercise program	$r = -0.691$	$r = -0.652$	$r = 0.603$	$r = 0.614$	$r = -0,625$	$r = -0.652$
	$P = 0.035$*	$P = 0.041$*	$P = 0,041$*	$P = 0.043$*	$P = 0.045$*	$P = 0.035$*
Pain after 4 weeks post exercise program	$r = -0.682$	$r = -0.361$	–	–	$r = -0.515$	$r = -0.542$
	$P = 0.041$*	$P = 0.048$*	–	–	$P = 0.044$*	$P = 0.046$*
Pain after 8 weeks post exercise program	$r = -0.663$	–	–	–	–	–
	$P = 0.042$*	–	–	–	–	–
Pain after 12 weeks post exercise program	$r = -0.591$	–	–	–	–	–
	$P = 0.044$*	–	–	–	–	–

Note: Only statistically significant values of correlation coefficients are shown in the table.
* $P < 0.05$ by correlation analysis.

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