



ORIGINAL ARTICLE

The Effects of Combining Core Stability with Stretching Exercises on Pain Intensity and Motor Function in People with Chronic Nonspecific Low Back Pain with and without Hyperlordosis

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ABSTRACT

Background. Low back pain is a significant issue in the field of health. Therefore, addressing new therapeutic approaches seems necessary. **Objectives.** The present study examined the effect of combining core stability with stretching exercises on pain intensity and motor function in people with chronic nonspecific low back pain with and without hyperlordosis. **Methods.** The research method was quasi-experimental, and its statistical population included adolescent girls with chronic low back pain with and without lumbar hyperlordosis in Lahijan schools (2018). Sixty qualified girls aged 12 to 15 years were purposefully selected based on inclusion and exclusion criteria and were randomly divided into four groups. Experimental groups with and without lordosis performed stretching-core stability exercises for eight weeks in three 45-minute sessions. At the beginning and end of the exercise period, the dependent variables were evaluated. **Results.** Students with and without lumbar arch enlargement who underwent therapeutic exercise experienced significant pain relief and lumbar arch reduction. Lumbar muscle strength was also increased compared to the control group ($p = 0.001$). However, there was a significant difference in static and dynamic balance variables between experimental and control groups without lordosis. Results also showed the effect of exercises in all variables between pre-test and post-test of the two experimental groups ($p = 0.001$). **Conclusion.** Combining core stability with stretching exercises can, in addition to improving chronic low back pain, reduce the severity of lumbar lordosis and the trunk muscle endurance and its balance.

KEYWORDS: *Lordosis, Balance, Muscle Endurance, Chronic Pain, Exercise.*

INTRODUCTION

Low back pain is a critical limiting factor in personal and social activities. About 60 to 90% of people experience it at least once in their lifetime, and it is often known as a benign disease, which is the focus of research because it involves pain. Many different therapeutic interventions are used to treat this disease, yet the effect associated with many of these interventions is still questionable and needs further research (1).

Proper functioning of the lumbar spine is essential during daily life activities. Therefore, strength, endurance, and overall posture of the spine are essential factors because the speed of rehabilitation or chronic back pain depends on the readiness and biomechanical features before suffering from low back pain (2). In this regard, in addition to its useful role in maintaining the body's balance, the lumbar lordosis can provide the necessary resistance to compressive forces

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caused by gravity while allowing the body to move and have certain flexibility. The balance of the pelvic muscles is one of the factors affecting the lordosis. An increased lumbar lordosis is one of the disorders of the lower cross syndrome (LCS) in which the posterior lumbar and anterior thigh muscles, especially the iliopsoas muscle, are shortened, and the abdominal, gluteal, and hamstring muscles become long and weak (3). Coordination between all trunk and thigh muscles is essential to control and maintain the normal position of the spine where no specific muscle is involved in increasing core stability. Also, the balance among the muscles on the four sides of the spine determines spinal stability (4). Many studies have pointed to the high prevalence of hyperlordosis in adolescents rather than other age groups, especially in girls. Numerous treatments such as rest, exercise therapy, traction, osteopathic therapy, manipulation therapy, massage, mobilization, and electrotherapy have been reported to treat low back pain. However, there is still no general consensus on which method is more effective in treating low back pain (5).

In order to use the most effective type of motor exercise, studies have shown that Mackenzie extension exercises could be effective in relieving pain, improving lumbar spine mobility, accelerating the return to daily activity, and minimizing referrals to medical centers and the number of treatment sessions for patients. Williams et al. also reported that lumbar lordosis was improved by using flexion exercises which had a significant effect on increasing the strength and endurance of the abdominal muscles, as well as reducing lumbar pain (5). On the one hand, researchers showed that more than 90% of patients improved after 6 months of participating in hydrotherapy program, and according to this report, hydrotherapy is an efficient treatment for patients with low back pain (6). Tubergen et al. compared the effect of hydrotherapy and exercise therapy program in patients with low back pain and showed that hydrotherapy had a significant effect compared to exercise therapy (7). On the other hand, by reviewing various researches in the field of exercise therapy, different and contradictory results were obtained in using traditional exercise methods such as Williams, Mackenzie and newer methods such as selected hybrid exercises, hydrotherapy, using unstable surfaces and their effects on reducing lumbar lordosis and low back pain (8).

Many studies have examined changes associated with low back pain, but the cause or effect of low back pain is still unknown due to changes in various parameters. They include rapid fatigue in the spinal stabilizing muscles or changes in the recruitment pattern of the muscles around the back and abdomen during daily limb activities and movements as well as delay in movement responses or static and dynamic balance reduction (9).

Patients' rehabilitation programs emphasize patient exercise and participation in the treatment process. Most studies focused on the effect of various motor interventions solely on the pain intensity of these patients (10). Nevertheless, changes in the spinal biomechanical parameters can cause and aggravate chronic low back pain, but few studies examined the underlying biomechanical factors involved in the onset of the symptoms (11). Therefore, it is necessary to provide movement protocols along with the evaluation of related biomechanical factors. Notably, a review of previous studies shows that no study has compared the effect of exercise interventions in patients with chronic low back pain with and without an enlarged lordosis. Therefore, the present study compares the effect of selected stretching-core stability exercises on pain intensity and motor function in patients with chronic nonspecific low back pain with and without hyperlordosis.

MATERIALS AND METHODS

Study Design and Ethical Considerations.

This is a quasi-experimental study with a research project, pre-test and post-test with a control group. This research received the code of ethics from the ethics committee of the Physical Education Research Institute No. IR.SSRI.REC.1397.269.

Participants and Study Process. From all female students with chronic low back pain studying in schools in Lahijan in 2018, 60 subjects are selected based on the inclusion and exclusion criteria of this study. The number of samples is calculated using G-Power software with 80% power and 0.05 reliability according to previous researches (10). According to the targeted evaluations, 60 students had non-specific chronic low back pain, 15 had a lumbar lordosis above 42° (12) and 30 had normal lumbar lordosis. All of them had a history of chronic low back pain for more than three months with a specialist's confirmation. By completing the consent form, the

subjects are randomly divided into four groups of 15 (two experimental and two control groups). The two experimental groups with and without lumbar lordosis received stretching-core stability exercises for eight weeks and the control group did not perform any exercise programs. Before starting the research steps, first the goal of the research and the method of performing the tests were explained to the subjects, and then the pain intensity, lumbar lordosis, central trunk muscle endurance on all four sides and static and dynamic balance were evaluated. The subjects are reevaluated after the exercise period. Exercise interventions are performed carefully under the supervision of the researcher for the experimental groups in the school hall for eight weeks and three days a week for forty-five minutes, while the control group did not perform any exercise program during this period. The overload principle of workout is observed by reducing the rest time and increasing the number of sets and repetitions. The workout program consists of three parts: warming up, the main workout (Table 1) and cooling down. Exclusion criteria for subjects include: nonspecific low back pain with lumbar lordosis less than 42 degrees (for the group with lumbar lordosis), specific low back pain, pregnancy, rheumatic diseases, vertebral fractures, osteoporosis, spinal surgery, severe postural deformity, congenital spine anomalies, spina bifida, spondylolysis, shooting pain in the legs, severe night pain, depression and a history of mental problems, infectious diseases, a history of regular exercise and the use of anti-inflammatory and analgesic drugs. All dependent variables were evaluated before and after the implementation of the eight-week exercise protocol. Shapiro Wilk statistical test was used to investigate the normal distribution of quantitative variables. To compare the main variables of the study before and after stretching - core stability exercises between and within groups, dependent t-test and MANCOVA and control of matching background variables were consulted through independent t-test in SPSS 21.

Combined Stretching – Core Stability Exercises. These exercises include two parts: core stability exercises for strengthening the abdominal weak muscles and stretching exercises for eliminating muscle shortness in the lumbar and pelvic sets as follows (5):

The overload principle of the exercises was observed by increasing the iterations of

movements and keeping the muscle contraction, so that in the muscle strengthening exercises in 3 sets, the contractions started by holding for 10 s and gradually increased to 35 s in the last week.

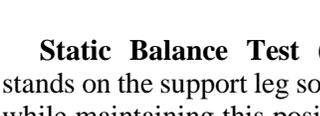
In the stretching exercises, the overload principle was observed by increasing the repetition, so that the stretching exercises started in 3 sets from the first week with 10 iterations and then gradually reached 30 iterations. **Evaluation of lumbar lordosis.** The lumbar lordosis was measured with a flexible ruler from the first lumbar region to the second sacrum in a standing position, similar to the method adopted by Levin et al. (12). To increase the accuracy of each subject, the test was performed twice and in case of discrepancy, the third test was recorded for statistical calculations. The theta curvature angle was calculated using the following formula and the subjects were people with chronic low back pain with a lumbar lordosis angle of more than 42° (13).

$$\theta = 4 \arctan \left(\frac{2h}{L} \right)$$

Evaluation of Lumbopelvic Stabilizer Muscle Endurance. McGill tests were used to evaluate the endurance of the muscles in the central part of the trunk. McGill et al. (1999) reported a reliability of 0.93 for this test. To measure the endurance of the anterior trunk stabilizer muscles, the trunk flexor test with a reliability of 0.98 was employed (9). Side bridge test (left and right) was run to measure the side trunk stabilizing muscle endurance with a reliability of 0.95 (14). To evaluate the tests, time was recorded using a stopwatch. The total trunk stabilizer muscle endurance in all dimensions (posterior, anterior and side) was also used as a single unit (15). The validity and reliability of this test was confirmed in measuring the erector spine muscles endurance and its reliability was reported to be 88% in people with low back pain (16).

Quebec Back Pain Test. This scale contains 25 five-choice questions (0-4) that rank pain intensity between 0 and 100. A zero indicates complete and painless health, a rank of 25 represents moderate pain, a rank of 50 signals high pain, and 75 or higher indicate severe pain. In this study, people with low back pain intensity above 50 were selected (17, 18). The validity and reliability of the Quebec scale in measuring low back pain was reported to be 80% (19).

Table 1. Combined Stretching- Core Stability Exercises

Images	Procedure	Exercises
	The person is lying on his/her back with bent knees and does the exercise by contracting the abdominal and lumbar muscles and then relaxing it	Contraction and relaxation of the abdominal and lumbar muscles
	The person was asked to face up, with both feet bent at the knees and the soles on the floor. Once both legs were bent to the left from the pelvis and once to the right. This movement was performed quite slowly	Strengthening the muscles on both sides of the back
	Being on all fours position and raising the congruent arm and leg. Once with the right foot and once with the left foot	Abdominal crunch
	In on-all-fours position, one opposite arm and one leg were straightened from the thighs and shoulders	Raising the opposite arm and leg
	Being on all fours position, the person raises the congruent hand and foot and bends the knee once with the right foot and once with the left foot	Raising the congruent hands and feet
	In face-up position, bridge with the bent knee and the abdominal and pelvis muscles are contracted	Bridging while facing up with the knee bent
	Lying on back, the person bends knees and cross arms over chest, and maintains trunk flexion at 60 degrees.	Exercising the endurance of flexor muscles of the trunk
	Bridging is performed in the side position	Endurance training of lateral flexor muscles of the trunk
	The person lies on his back on the ground and throws his right foot on his left foot. Then, she grabs the back of his left foot with her hands. In this situation, the person pulls both feet towards the waist with her hand.	Piriformis stretch
	The person was asked to face up and move her knees as close to the chest as possible. The purpose of this operation is to create stretch and flexibility in the muscles and elements around the spine (once the right leg and once the left leg)	Stretching the erector spine muscles
	She was asked to face up and bend both knees in the chest. (Simultaneously right and left).	Stretching the lumbar spine extensor muscles
	In this case, the person is on the palms and knees and begins to move by creating relaxation and then contracting lumbar muscles.	The cat camel movement

Static Balance Test (Stork). The subject stands on the support leg sole as much as possible while maintaining this position while placing her hands on waist and placing the sole of the non-supportive foot on the inner thigh area of the support foot besides the knee. During the test, the subject looks at the mark in front of her face at a distance of 4 m. The time to maintain this position is recorded as a score and each subject makes three attempts during which the best time is recorded as the subject score (5).

Dynamic Balance Test (Star). To measure this test, the distance traveled by each subject's moving foot in all eight directions was calculated at a 45 ° angle. Before performing the test, the actual length of the foot, from ASIS to the medial ankle, was measured to normalize information. For each subject, the superior foot was identified. If the right foot was superior, the test was performed counterclockwise, and if the left foot was superior, the test was performed clockwise. For normalization, the mean access distance was

divided into the leg length and multiplied by 100 to obtain the access distance as a percentage of the foot length (20, 21). After each test, at least 5 minutes were left for relaxing until the next test was performed. The order of the test evaluation was as follows: first static balance and then dynamic balance were evaluated.

RESULTS

The results of the normality test showed that the data were normally distributed in all variables in both groups ($P > 0.05$). Comparison of the characteristics of the four groups in terms of age, height, weight, body mass index, lumbar lordosis angle, lateral spinal muscle endurance, flexor endurance, extensor and pain intensity and static and dynamic balance at the inclusion to the study were not significantly different. Also, by examining the Levene's test for all variables, it was observed that there is a condition of homogeneity of variances. Table 2 shows the mean and standard deviation of the subjects' demographic characteristics, including height, weight, age, and duration of chronic low back pain, and BMI.

Table 3 shows the comparison of mean and standard deviation of pre- and post-test of lumbar lordosis intensity and pain, central trunk muscle endurance and static and dynamic balance of experimental and control groups with and without lumbar lordosis affected by the selected hybrid exercises.

According to Table 4, the results of the present study showed that a comparison of the mean results between the experimental and control groups of patients with low back pain with lumbar lordosis under the influence of eight weeks of stretching-core stability exercises showed a significant difference in pain intensity, lordosis angle and central muscle endurance ($p < 0.05$). In addition, comparison of the mean results between the experimental and control groups of patients with low back pain without lumbar lordosis under the influence of eight weeks of stretching - core stability exercises showed a significant difference in all variables ($p < 0.05$).

DISCUSSION

Results showed that the stretching-core stability protocol used in this study had a significant effect on the improvement of the pain intensity and lordosis angle, spinal flexor and extensor endurance of girls with chronic low back pain with and without lumbar lordosis; however, this protocol could only affect the improvement

of static and dynamic balance in girls with chronic low back pain without lumbar lordosis.

The structure of the lumbar vertebrae is fundamentally unstable, and as a result of increasing and maintaining the stability provided by the promotion of the muscular system around them by some exercise programs, it can improve the physical condition and motor function of individuals (2). The results of the present study also confirm this issue. In this regard, the rehabilitation of patients with chronic low back pain aims to restore strength, endurance and flexibility of damaged soft tissues in these people. Therefore, by prescribing stabilizing exercises in the central region, it increases the strength and endurance in the trunk central part muscles, which reduces the tension in the ligaments and joints of the vertebral column. As a result, it stabilizes them in a normal position and reduces pain and increases the patient's trust in the treatment method. Researchers have linked the pain reduction to the optimal function of the transverse abdominal and multifidus muscles because the transverse abdominal muscle is key in maintaining the spine. Training on its facilitation is the first step in relieving low back pain (2).

The results of this study show that the pain intensity in people with chronic low back pain with and without lumbar lordosis decreased significantly under the influence of stretching-core stability exercises, which is in line with the results of studies by Moon et al (20). In this regard, the present study also showed that enhancing the total endurance of the trunk stabilizing muscles is significantly associated with reducing pain intensity. The interaction between pain and muscle force is involved in the mechanism of low back pain and its progression. It may initially cause pain due to muscle weakness and mechanical pressure on the trunk, as a result of which muscle activity is avoided. Evidently, many patients with chronic low back pain are afraid of movements involving the spine, and a kind of double muscle weakness also occurs in these patients. These two phenomena put a person in a vicious cycle and cause chronic diseases (22). In this regard, Park et al. (2013) proposed practical exercises to reduce disability and increase the thickness of the transverse abdominal and external oblique muscles by maneuvering abdominal sucking-in and increasing the thickness of the internal oblique with other core stability exercises (23). Another study also stated that decreased endurance of the

lumbar spine could be due to muscle atrophy following immobility, thereby increasing the

forces on the lumbar spine and leading to low back pain (24).

Table 2. Demographic Data of the Subjects in Each of the Four Test and Control Groups

Variable	Experimental with Lordosis (n = 15)		Experimental Without Lordosis (n = 15)		Control with Lordosis (n = 15)		Control Without Lordosis (n = 15)		P
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Age (year)	13.00	0.65	12.73	0.88	13.20	0.86	12.80	2.23	0.27
Weight (kg)	57.68	64.4	58.13	15.21	58.26	13.99	55.66	16.08	0.55
Height (cm)	160.60	9.60	158.13	5.66	160.53	6.46	159.67	6.81	0.46
BMI	25.01	3.67	23.18	5.88	22.47	4.46	21.64	5.37	0.59

Table 3. Comparison of Pre- and Post-Test Results of Dependent Variables in Experimental and cControl Groups

Variable	Mean	SE	t	df	p	
Pain intensity						
Experimental with lordosis				21.481	14	0.001*
Pre-test	67.26	11.19				
Posttest	9.53	2.97				
Control with lordosis			-1.762	14	0.100	
Pre-test	56.26	20.22				
Posttest	59.06	18.59				
Experimental without lordosis			8.95	14	0.001*	
Pre-test	59.80	17.14				
Posttest	14.60	6.57				
Control without lordosis			0.557	14	0.587	
Pre-test	59.20	17.58				
Posttest	58.53	17.29				
Lumbar lordosis angle(deg)						
Experimental with lordosis			12.557	14	0.001*	
Pre-test	62.25	3.88				
Posttest	51.71	3.41				
Control with lordosis			12.335	14	0.219	
Pre-test	62.25	3.88				
Posttest	53.20	3.41				
Experimental without lordosis			10.534	14	0.001*	
Pre-test	37.78	7.61				
Posttest	31.12	7.50				
Control without lordosis			1.712	14	0.109	
Pre-test	46.34	45.34				
Posttest	13.20	3.17				
Trunk extensor endurance(s)						
Experimental with lordosis			-4.836	14	0.001*	
Pre-test	75.60	15.07				
Posttest	127.46	40.08				
Control with lordosis			0.685	14	0.505	
Pre-test	138.33	77.90				
Posttest	136.93	79.91				
Experimental without lordosis			-2.968	14	0.01*	
Pre-test	119.80	46.71				
Posttest	157.13	67.15				
Control without lordosis			-0.835	14	0.418	
Pre-test	131.40	59.72				
Posttest	134.80	50.41				
Trunk flexor endurance(s)						
Experimental with lordosis			-6.321	14	0.001*	
Pre-test	94.33	20.85				
Posttest	143.73	19.91				
Control with lordosis			-1.706	14	0.099	
Pre-test	96.20	21.39				
Posttest	102.200	19.48				

*significant at $p < 0.05$.

Table 3. Continued

Variable	Mean	SE	t	df	p
Experimental without lordosis			-4.281	14	0.001*
Pre-test	197.73	93.47			
Posttest	245.06	88.76			
Control without lordosis			0.960	14	0.353
Pre-test	187.53	92.59			
Posttest	181.00	87.57			
Endurance of right lateral flexor(s)					
Experimental with lordosis			-10.920	14	0.001*
Pre-test	59.53	14.32			
Posttest	79.60	13.33			
Control with lordosis			-2.755	14	0.160
Pre-test	58.20	11.31			
Posttest	61.13	13.25			
Experimental without lordosis			-14.368	14	0.001*
Pre-test	64.33	24.95			
Posttest	88.93	25.40			
Control without lordosis			0.221	14	0.829
Pre-test	87.13	28.33			
Posttest	86.80	26.32			
Endurance of left lateral flexor(s)					
Experimental with lordosis			-7.498	14	0.001*
Pre-test	49.20	13.54			
Posttest	66.13	11.51			
Control with lordosis			-7.498	14	0.100
Pre-test	49.20	13.54			
Posttest	66.13	11.51			
Experimental without lordosis			-8.573	14	0.001*
Pre-test	52.26	17.01			
Posttest	73.93	16.62			
Control without lordosis			1.291	14	0.218
Pre-test	70.86	19.31			
Posttest	68.73	19.12			
Static balance(s)					
Experimental with lordosis			-5.484	14	0.001*
Pre-test	80.46	23.63			
Posttest	86.66	23.13			
Control with lordosis			0.645	14	0.529
Pre-test	80.46	23.63			
Posttest	74.06	24.22			
Experimental without lordosis			-7.257	14	0.001*
Pre-test	55.73	16.91			
Posttest	65.06	16.85			
Control without lordosis			-0.373	14	0.715
Pre-test	74.26	25.74			
Posttest	74.66	26.01			
Dynamic balance(cm)					
Experimental with lordosis			-5.074	14	0.001*
Pre-test	87.22	4.07			
Posttest	91.49	6.05			
Control with lordosis			0.083	14	0.935
Pre-test	87.22	13.20			
Posttest	86.82	19.10			
Experimental without lordosis			-21.746	14	0.001*
Pre-test	89.98	5.78			
Posttest	95.57	5.65			
Control without lordosis			0.115	14	0.910
Pre-test	86.95	6.42			
Posttest	86.92	6.43			

*significant at $p < 0.05$.

Table 4. Comparison of the Results of Variables between Experimental and Control Groups with and Without Lumbar Lordosis

Variables	Mean Square	f	Sig
Pain intensity			
Between groups with lordosis	247.849	46.181	0.001*
Between groups without lordosis	11838.267	13.482	0.001*
Lumbar lordosis angle (deg)			
Between groups with lordosis	30.256	11.228	0.001*
Between groups without lordosis	274.073	69.900	0.001*
Trunk extensor endurance (s)			
Between groups with lordosis	10081.107	9.238	0.001*
Between groups without lordosis	9722.513	9.339	0.001*
Trunk flexor endurance(s)			
Between groups with lordosis	1135.869	3.172	0.016*
Between groups without lordosis	25066.181	21.929	0.001*
Endurance of right lateral flexor(s)			
Between groups with lordosis	499.183	20.519	0.001*
Between groups without lordosis	2014.197	62.582	0.001*
Endurance of left lateral flexor(s)			
Between groups with lordosis	348.732	12.175	0.001*
Between groups without lordosis	850.048	11.024	0.001*
Static balance(s)			
Between groups with lordosis	579.074	0.991	0.477
Between groups without lordosis	1519.932	65.503	0.001*
Dynamic balance(cm)			
Between groups with lordosis	328.211	0.903	0.541
Between groups without lordosis	174.051	157.397	0.001*

*significant at $p < 0.05$

In contrast, Lederman et al. (2008) did not consider the abdominal muscles to be effective in creating core stability and did not state the role of core stability exercises or strengthening the trunk muscles in preventing or treating chronic low back pain more effective than other exercises (25). Manion et al. (2001) do not consider trunk muscle strengthening to be effective in relieving pain or improving disability in people with chronic low back pain (26). The reason for the differences in the results obtained in these studies is probably due to differences in the type of equipment and tools used to measure core stability and sample selection, as well as the use of methods and training programs and the number of training sessions. Koumantakis et al. also examined the effect of a period of endurance and stability exercises on patients with chronic low back pain and concluded that there was no significant difference between the two training methods in back muscle strength and endurance. Also in the same year, the researchers examined the effect of an eight-week combination of stability training and general exercise versus general exercise alone on 55 patients with low back pain. The results showed that general exercise would have more lasting results than stability exercises in patients with low back pain (27). The reason for the inconsistency of the

results of Koumantakis et al. with this study was probably due to the dissimilarity of the type of exercises on influencing the trunk muscles and the number of training sessions.

Therefore, according to the results of these studies, it can be inferred that people with chronic low back pain have weak strength and endurance of the trunk muscles or the stabilizing muscles of the central area. In this study, along with the improvement in endurance of the total stabilizing muscles of the central area, a significant decrease was observed in the pain intensity of the subjects. Therefore, it can be said that the effectiveness of exercises similar to those in this study can be due to an increase in muscle endurance in the trunk lateral flexion muscles in addition to enhancing the bearing capacity of the trunk flexor extensor muscles. Consequently, the overall stability of the trunk will be doubled under the effect of this method (28). In people with low back pain, the pattern of movement and the use of deep back muscles – responsible for maintaining the stability of the lumbar spine – changes, so more attention should be paid to exercise programs aimed at improving the lumbar spine stability and adopting them in the treatment of these patients. For this purpose, it is necessary to perform stability exercises for training and retraining trunk muscles and controlling extra movements in this

area and thus reducing pain and disability in patients with low back pain (20). In other words, by arousing the intersegmental muscles, these exercises lead to higher segmental stability and the creation of a stable central system. Thus, it can improve postural stability of the person with increased lumbar lordosis and balance and more proper motor function (21).

In line with the results of this study on the effect of exercise on pain intensity and improving endurance of lumbar extensor muscles, we can refer to the results of Kim et al. (2010) which compared the effects of backward movement in water and resistance training in water on pain and lumbar extension strength in patients with a herniated disc with a history of surgery (29). Despite the differences in the subjects, the type of exercise program (hydrotherapy) and the duration of training sessions, the reason for the concordance of their results can be the principle of exercise specificity, where trunk muscle strengthening exercises are used in both studies .

The results of this study show that in the nonspecific low back pain group, a weaker balance is observed despite hyperlordosis, which can be attributed to the inhibitory role of low back pain in the activities of people with hyperlordosis. In people with poor core stability, the balance also decreases due to weaker function of these muscles. Coordinated function of the stabilizing muscles leads to optimal arthrokinematics in the thigh, lumbar and pelvic joints during functional activities and provides proximal stability for lower limb movements. Proper flexibility of the lumbar and hamstring muscles also plays an important role in preventing lumbar and pelvic injuries. In this respect, many back pains are due to reduced muscle flexibility in this area (30). However, the review of previous researches in this field shows contradictory results and it seems that the reason for the contradiction in the results can be attributed to the differences in their methodology. Sato et al. (2008) reported no significant improvement in lower limb stability under the influence of deep muscle stabilization exercises (31).

The variety of different tools in measuring posture control and balance as well as different age range of the subjects can affect the inconsistency in the research; some researchers have considered the early ages of the growth period while others have considered the final ages of the same period. This issue, along with the individual differences of

the subjects, can affect the research results. Since there are few studies that have exactly the same research method and subjects, results have been reported differently. Some studies have focused on the effect of postural changes on maintaining body balance, indicating the negative effect of adverse posture on body balance control. One of the possible reasons for the decrease in balance with changes in the spinal curvature may be due to the displacement of the center of gravity forward and down (32). It is also due to incorrect information sent from the balance control systems to the central nervous system. On the other hand, one of the causes of disorders in the vestibular system, which is one of the balance control systems, is that with the emergence of abnormalities in the spine, especially kyphosis and scoliosis, the initial position of the head on the spine changes. This change initiates incorrect information transmission to central nervous system and the body may fluctuate more while maintaining balance. If the symmetry of the muscles and the position of the joints change from the initial state, the sensory system is disrupted and may not transmit accurate information about the position of the muscles and joints to the central nervous system. With the exacerbation of the round back or kyphosis, the position of the spine and the agonist and antagonist muscles may change relative to each other. In addition, articular and muscular receptors do not transmit the correct information which leads to a disturbed balance. Lack of muscle coordination in people with spinal abnormalities can be another reason for the disturbed balance in people with hyper kyphosis. With the development of spinal abnormalities, the muscles of one side become short and the other side becomes weak. As a result of this condition, there is a lack of coordination or muscle imbalance between these muscles during activity, and inappropriate movement patterns would be created (32, 33). Restriction of spinal movement in people with low back pain may also decrease balance in these people, because with the motor restriction in the spine during the balance tests, the spine cannot perform the necessary movements and the person may have an impaired balance (34).

In line with the results of this training protocol, we can point to the effect of stretching exercises, especially on the hyperlordotic group, considering that the most common cause of low back pain in school-age children is acute or subacute musculoskeletal pain with an unknown

cause. Short thoracolumbar fascia resulting from rapid growth can be combined with segmental flexibility in this area and lead to hyperlordosis and thoracic kyphosis, which can in turn cause hyperlordosis syndrome (35). Due to the scarcity of documents related to the effect of spinal deformities on postural control, it seems necessary to conduct similar studies with more accurate postural control evaluation methods.

Therefore, in controlling low back pain in people with lumbar hyperlordosis, it is important to design appropriate exercise programs to strengthen the core stability muscles to improve the locomotor system function. However, despite many studies on low back pain, less attention has been paid to the underlying biomechanical factors for various reasons and there is still no consensus on the most appropriate therapeutic intervention (17). Therefore, there is still a need for research on the specific biomechanical conditions of patients with low back pain such as presence or absence of increased lumbar lordosis, short iliopsoas and hamstrings (36, 37). Also, many patients want a faster return of functional abilities, pain reduction and increased muscle function for various reasons, especially economic reasons, making many researchers look for new scientific methods to bear favorable results.

A limitation to the present study was the small number of samples, which could be justified according to the inclusion and exclusion criteria, so that the subjects should have chronic non-specific low back pain with lumbar lordosis over 42 °. Another limitation was the age range of 12 to 15 years of the subjects, which included students.

CONCLUSION

Low back pain is common in school students for unknown causes and most of them are benign with musculoskeletal causes. In this society,

special attention should be paid to the identification, evaluation, development and treatment of low back pain. Research is also needed to identify the factors involved in causing low back pain to develop better evidence-based methods for treatment. The effectiveness of exercises in this study could be due to the combination of stretching and core stability exercises, so that in addition to increasing the flexor and extensor muscle endurance, it strengthens the trunk lateral muscles and doubles the stability of the trunk. On the other hand, combining these exercises with stretching movements in the dorsal spine can affect the effectiveness of these exercises.

APPLICABLE REMARKS

- In people with low back pain, the motor pattern and deep trunk muscles, which are responsible for maintaining the stability of the lumbar spine, change. Thus, more attention should be paid to exercise programs aimed at improving the lumbar spine stability and use them more widely in the treatment of these patients. For this purpose, it is necessary to perform stabilization exercises for training and retraining trunk muscles and control of extra trunk movements, and reduction of pain and disability in patients with low back pain, consequently.

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