ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.31609/jpmrs.2024-106369

The Efficacy of Core Stabilization Exercises on Disability and Hip Muscle Strength in Patients with Nonspecific Low Back Pain

Nonspesifik Bel Ağrılı Hastalarda Kor Stabilizasyon Egzersizlerinin Engellilik ve Kalça Kas Gücü Üzerine Etkisi

Ahmet Cemal KAYA[a], Ali Erdem BAKİ[b], Gülşah AKGÜN ALTAN[c], Elif Nurdan GÜNEŞ KAYA[d], Mehmet OKÇU[a]

[a]Şanlıurfa Mehmet Akif İnan Training and Research Hospital, Clinic of Physical Medicine and Rehabilitation, Şanlıurfa, Türkiye
[b]Ankara University Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Ankara, Türkiye
[c]Çanakkale Mehmet Akif Ersoy State Hospital, Clinic of Physical Medicine and Rehabilitation, Çanakkale, Türkiye
[d]Suruç State Hospital, Clinic of Physical Medicine and Rehabilitation, Şanlıurfa, Türkiye

ABSTRACT Objective: In this study, we aimed to investigate the efficacy of core stabilization exercises on functional disability, pain, hip muscle strength, and core stability in patients with chronic nonspecific low back pain (LBP). **Material and Methods:** A total of 26 individuals with chronic nonspecific LBP were enrolled in this study. The patients performed lumbar stabilization exercises for three weeks with a physiotherapist and five weeks as a home program. Assessments were made at pre-treatment, at week 3, and at week 8. Outcome measures were functional status [Roland Morris Disability Questionnaire (RM) and Oswestry Disability Index (ODI)], pain visual analog scale (VAS), transversus abdominis (TA) activation (prone TA test), core muscle strength and endurance (leg lowering test, prone bridge test, and supine bridge test, lateral muscular test and flexor endurance test), hip muscle strength (MicroFET3 manual dynamometer). **Results:** Following treatment, there was a significant improvement in VAS movement, VAS resting, ODI and RM scores, TA activation, leg lowering test, and core endurance test times compared to baseline. Hip muscle strength improved in all directions except left external and right internal rotation. **Conclusion:** It should be noted that lumbar stabilization exercises are effective treatment methods for patients with chronic nonspecific LBP. These exercises improve functionality, core endurance, and increase hip muscles strength.

Keywords: Core stabilization; lumbar stabilization; exercise therapy

ÖZET Amaç: Bu çalışmada, kronik nonspesifik bel ağrısı (KBA) olan hastalarda lomber stabilizasyon egzersizlerinin hastaların fonksiyonel durumu, bel ağrısı, kalça çevresi kas gücü ve kor enduransı üzerine etkinliğinin araştırılması amaçlanmıştır. **Gereç ve Yöntemler:** Çalışmamıza nonspesifik KBA'sı olan 26 hasta dâhil edildi. Hastalara 3 hafta fizyoterapist eşliğinde sonrasında 5 hafta ev programı şeklinde toplam 8 hafta boyunca lomber stabilizasyon egzersizi uygulandı. Hastalar başlangıçta, 3 hafta sonra ve 8 hafta sonra değerlendirildi. Ağrı için görsel analog skala [visual analog scale (VAS)], engellilik için Roland Morris Yetersizlik Anketi (RM) ve Oswestry Yetersizlik Anketi [Oswestry Disability Index (ODI)] kullanıldı. Transversus abdominis (TA) aktivasyonunu değerlendirmek için yüzüstü TA testi, kor kas gücünü değerlendirmek için bacak indirme testi uygulandı. Kor enduransı, fleksör dayanıklılık testi, lateral musküler test, supin bridge test ve prone bridge test ile değerlendirildi. Kalça çevresi kas gücü, MicroFET3 manuel kas dinamometresi ile değerlendirildi. **Bulgular:** Tedavi sonrası VAS hareket ve VAS istirahat skorları başlangıca göre anlamlı düzeyde azaldı. Oswestry Yetersizlik Anketi ve Roland Morris Yetersizlik Anketinde 8. haftadaki iyileşme başlangıca göre anlamlı bulundu. TA aktivasyonunda, leg lowering testinde ve kor dayanıklılık testi sürelerinde 8. hafta sonunda başlangıca göre anlamlı artış saptandı. Sol kalça dış rotator ve sağ kalça iç rotator kas gücü hariç kalça çevresi kas gücü değerleri; 8. hafta skorlarında başlangıca göre anlamlı artış saptandı. **Sonuç:** Lomber stabilizasyon egzersizlerinin kronik nonspesifik bel ağrısında ağrı ve fonksiyonellik üzerine etkili bir tedavi yöntemi olduğu akılda tutulmalıdır. Ayrıca kor dayanıklılığında iyileşme ve kalça çevresi kas gücünde de artış sağlamaktadır.

Anahtar Kelimeler: Kor stabilizasyon; lomber stabilizasyon; egzersiz tedavisi

Correspondence: Mehmet OKÇU
Şanlıurfa Mehmet Akif İnan Training and Research Hospital, Clinic of Physical Medicine and Rehabilitation, Şanlıurfa, Türkiye
E-mail: dr.okcu@gmail.com

Peer review under responsibility of Journal of Physical Medicine and Rehabilitation Science.

Received: 31 Oct 2024 ***Received in revised form:*** 06 Mar 2025 ***Accepted:*** 11 Mar 2025 ***Available online:*** 20 Mar 2025

Low back pain (LBP) is a common health problem, with 84% of individuals experiencing it at some point in their lives.[1,2] It is more prevalent among women, particularly in the age range of 40-69 years.[3] Chronic nonspecific LBP is a significant clinical, social, economic, and public health issue.[4]

LBP lasting more than 3 months or recurring episodically within 6 months is defined as chronic LBP.[5] In 90-95% of cases of LBP, no underlying cause is found to explain the pain.[6] Mechanical causes are the primary factor in the development of LBP. When there is no underlying pathology, it is referred to as "nonspecific LBP".[6]

In the management of LBP, a multimodal and multidisciplinary approach is recommended. This includes patient education, pharmacological treatments, injection methods, exercise therapy, group exercise programmes, back schools, massage, kinesio tape, spinal manipulation and mobilization, and psychological therapies combined with other treatments.[7,8]

Various therapeutic exercise methods are commonly used to treat LBP.[9,10] The lumbar stabilization exercise program involves activating pelvic floor (PF) muscles and lumbar multifidus (LM), transversus abdominis (TA) to stabilize the lumbar region. The program aims to stabilize the trunk, increase aerobic capacity, facilitate neuro-muscular control, and enhance the endurance and the strength of the trunk muscles and PF muscles, thereby stabilizing the spine.[11,12] Furthermore, stabilization exercises instruct individuals to utilize the neutral position of the lumbar region, thereby reducing the strain on dynamic and static structures.[13] Core stabilization has a wide range of benefits. These include improving athletic performance, preventing injuries, and alleviating LBP.[14]

This study aims to evaluate the efficacy of lumbar stabilization exercises in patients with chronic nonspecific LBP, focusing on their effects on pain reduction, core endurance, functional status, and hip muscles strength.

MATERIAL AND METHODS

The study was designed as a prospective investigation. From July to November 2018, we included 26 volunteers (12 males, 14 females) with chronic LBP who met the inclusion and exclusion criteria. These patients were selected from those who sought treatment for chronic LBP at the Physical Medicine and Rehabilitation Clinic of Zonguldak Bülent Ecevit University Hospital Hospital.

The study included patients aged 18 to 55 with chronic nonspecific low back pain. Patients with peripheral and spinal arthritis, acute radicular pain, a history of spinal surgery, motor or neurological deficits developed in the last 3 months, systemic infection, cardiovascular or pulmonary disease contraindicating exercise, spinal pathologies with red flag signs, pregnancy, or non-compliance with core stabilization exercise were excluded. The patients were informed both verbally and in writing and signed the minimum informed consent form prepared according to the study protocol. The study was approved by Clinical Research Ethics Committee of Zonguldak Bülent Ecevit University Faculty of Medicine (date: June 20, 2018; no: 2018-163-20/06) and performed in accordance with the ethical standards of the Declaration of Helsinki.

PROCEDURE

Questioning and physical examination related to the study were conducted, and a case report form was completed. The form included demographic information (age, gender, occupation, education level), pain duration, body mass index, and lifestyle factors (smoking and alcohol use). All participants underwent pain assessment, functional assessment, lumbar core assessment (including core endurance tests) and hip muscle strength assessment before the exercise, 3 weeks and 8 weeks after the exercise.

All patients underwent lumbar core stabilization exercises to increase the co-activation of the diaphragm, LM, PF, and TA muscles. The exercises were conducted at the Physical Medicine and Rehabilitation Clinic of Zonguldak Bülent Ecevit University Hospital for 3 weeks, with 45-minute sessions 3 times a week, under the supervision of a physiotherapist, as recommended by Dülger et al.[15] Subsequently, the patients continued the same exercise program at home, 3 days a week, for 5 weeks. The study participants were instructed to maintain their

regular medication regimen and daily routines without any modifications or alterations.

ASSESSMENT PARAMETERS

Visual Analogue Scale: To evaluate pain intensity experienced by patients, they were requested to indicate their pain severity (during movement, at rest, and at night) on a 10 cm horizontal ruler. The ruler was marked with 0 indicating no pain and 10 indicating severe pain.[16]

Oswestry Disability Questionnaire: The Oswestry Disability Questionnaire comprises 10 questions, each with 6 options ranging from 0 to 5 points, evaluating personal care, pain, weight lifting, standing, sitting, sleeping, walking, traveling, sexual life, and social life. A score of 0-14 indicates mild, 15-29 indicates moderate, and above 30 indicates severe functional limitation. The questionnaire has been validated in Turkish.[17]

Roland Morris Disability Questionnaire: The 24-item form assesses activities of daily living, body movements, activity level, eating, and sleeping. A score of 1 is given for each "yes" response, with a total score ranging from 0 (no disability) to 24 (severe disability).[18]

Leg Lowering Test: The leg lowering test is a useful tool for evaluating core muscle strength.[19] The patient was positioned in a supine position and a stabilizer (pressure biofeedback device) was placed under the low back. The pressure of the stabilizer was increased to 40 mm Hg. The patient's knees were brought to full extension and their hips were flexed at 90 degrees. The patient was instructed to draw their abdomen inwards, straighten their lower back as much as possible, and press the cuff. The patient was instructed to maintain a straight waist while lowering their legs towards the table. The test concluded when the cuff pressure decreased. Subsequently, the hip angle was measured using a goniometer and rated on the Kendall Scale.[19] This test measures the strength of the abdominal muscles. The results are categorized as follows: 15-0 is considered normal, 30-15 is good+, 45-30 is good, 60-45 is good-, 75-60 is weak+, and 90-75 is weak.

***Prone TA Test*:** The prone TA test evaluates an individual's capacity to contract the TA muscle and draw in the abdomen. A decrease in pressure of 4-10 mm Hg without any movement in the pelvis or spine is considered normal and indicates appropriate neuromuscular control of the TA.[19,20]

The prone TA test was conducted with the patient lying face down. A stabilizer was placed between the umbilicus and anterior superior iliac processes.[19] The stabilizer cuff was then inflated to 70 mm Hg. The patient was asked to breathe easily and then pull their abdomen inward without breathing. The patient was then asked to maintain this contraction for 10 seconds before slowly and deliberately releasing it. The pressure variation in the stabilizer was recorded.

Lateral Bridge Test: The patient was instructed to position themselves on their elbow to form a side bridge, with their legs aligned with their trunk. The patient was asked to place the upper arm on the opposite shoulder.[21] The patient was asked to lift their hips off the floor to form a straight line along the entire body. When the patient could not maintain this position, the test was stopped and the duration of the attempt was recorded.

***Flexion Endurance Test*:** The patient was positioned on the stretcher with their trunk at a 60° angle and their knees and hips flexed at 90°. The test was concluded when the trunk fell below the 60° angle, and the time was recorded.[21]

Prone Bridge Test: The patient was instructed to stand facing downwards with their shoulders and elbows bent at a 90-degree angle and their trunk straight. The test was concluded when the patient was unable to maintain the position, and the time was recorded.[21]

***Supine Bridge Test*:** The patient was positioned supine with their knees bent at a 60-degree angle. They were then instructed to lift their hips off the floor while keeping their trunks parallel to their thighs, and to maintain this position. The test was terminated and the duration was recorded when the angle between the hip and thigh was broken.[21]

Hip Muscle Strength Assessment: Hip muscle strength was assessed using a microFET3 manual muscle dynamometer (Hoggan Health Industries, Salt Lake City, UT). Measurements were taken separately

for each direction of both hips. Bilateral hip muscles were measured 3 times, and the average of these measurements was recorded.[22]

STATISTICAL ANALYSIS

Statistical evaluation was conducted using SPSS® Version 22.0 (IBM® Corporation, Armonk, NY). Compliance with normal distribution was assessed using Shapiro-Wilk and Kolmogorov-Smirnov tests. Descriptive statistics (mean, number, standard deviation, percentage, maximum, and minimum values) were used to evaluate the data, and the Friedman test was used for analytical evaluations. The statistical significance level was set at $p<0.05$. A "post-hoc" Dunn's test was conducted to identify the origin of the variation in variables that showed a significant difference.

RESULTS

Table 1 presents demographic and clinical data of the patients. All participants completed the study.

No significant decrease was observed in VAS night values at week 8 compared to pre-treatment ($p=0.107$). However, there was a significant decrease in both VAS movement and VAS resting scores at week 8 compared to pretreatment ($p<0.001$ and $p=0.007$). RM and Oswestry Disability Index (ODI) were used to assess functional disability in LBP. The results showed a significant decrease at week 8 compared to pretreatment ($p=0.001$ and $p=0.003$). (Table 2)

TABLE 1: Demographic and clinical characteristics of patients

	Percentage	X̄±SD
Age (year)		35.9±8.7
Duration of symptom (year)		3.3±3.6
BMI (kg/M^2)		26.3±5.0
Gender		
• Female (n=14)	53.8%	
• Male (n=12)	46.2%	
Education		
• Primary school (n=1)	3.8%	
• Secondary school (n=4)	15.4%	
• High School (n=6)	23.1%	
• University (n=15)	57.7%	
Occupation		
• Unemployed (n=3)	11.5%	
• Housewife (n=5)	19.2%	
• Officer (n=11)	42.3%	
• Heavy duty worker (n=7)	26.9%	
Smoking		
• Smoker (n=9)	34.6%	
• Non-smoker (n=17)	65.4%	
Comorbidities		
• Yes (n=3)	11.5%	
• No (n=23)	88.5%	

n: Number, SD: Standard deviation; BMI: Body mass index

The endurance of core muscles was assessed through the flexor endurance test, prone bridge test, right and left lateral bridge tests, and supine bridge test. All test results showed a significant improvement at the 8th week compared to the beginning (Table 3). At week 8 compared to pre-treatment, a significant difference was found in the TA prone test and leg lowering test, whereas no significant difference was found at week 3 compared to pretreatment ($p=0.002$ and $p=0.381$) (Table 3 and Table 4).

Upon analysis of the changes in right hip muscle strength, a significant increase was observed in all directions except for the right internal rotator at week 8 compared to the pre-treatment. Similarly, analysis of the changes in left hip muscle strength revealed a significant increase in all directions except for the right external rotator at week 8 compared to the pretreatment (Table 5).

DISCUSSION

This study found that lumbar stabilization exercises reduced pain and improved functionality, hip muscle strength, and core endurance in individuals with chronic nonspecific LBP.

The positive effects of lumbar stabilization exercises in our study are consistent with those reported in the literature. Akhtar et al. conducted a randomized controlled study comparing core stabilization exercises with general exercises in patients with chronic nonspecific LBP.[23] The study included 60 patients who underwent lumbar stabilization exercises and 60 patients who underwent general lumbar exercises. Both groups received physical therapy methods such as therapeutic ultrasound and electrotherapy. At the 6-week follow-up, the core stabilization group showed a significant improvement in VAS values

TABLE 2: Pain and disability assessment results at baseline, 3rd week, and 8th week

Parameter	Baseline (W0) X̄±SD	Week 3 (W3) X̄±SD	Week 8 (W8) X̄±SD	X²	p value*	pα (W0-W3)	pα (W0-W8)	pα (W3-W8)
VAS movement	5.6±2.3	3.5±2.1	2.7±2.1	26.6	<0.001*	0.013α	<0.001α	0.332α
VAS resting	4.0±2.2	2.7±2.1	2.0±1.6	11.9	0.003*	0.157α	0.007α	0.802α
VAS night	3.3±2.6	2.4±2.3	1.8±1.5	4.5	0.107*	-	-	-
ODI	18.1±6.6	14.9±10.0	13.6±9.2	14.5	0.001*	0.095α	0.001α	0.381α
Roland Morris Disability Questionnaire	9.8±6.6	7.4±6.1	6.7±6.6	12.8	0.002*	0.066α	0.003α	0.895α

p: Statistical Tests: Friedman Test; pα: Dunn test; W0-W3: Baseline-week 3; W0-W8: Baseline-week 8; W3-W8: Week 3-week 8. SD: Standard deviation; X²: chi-square; VAS: Visual analog scale; ODI: Oswestry Disability Index

TABLE 3: Core test results at baseline, 3rd week, and 8th week

Parameter	Baseline (W0) X̄±SD	Week 3 (W3) X̄±SD	Week 8 (W8) X̄±SD	X²	p*	pα (W0-W3)	pα (W0-W8)	pα (W3-W8)
Flexor endurance test (sec)	33.8±30.2	48.2±36.4	54.5±39.6	30.9	<0.001*	0.003α	<0.001α	0.080α
Left lateral muscular test (sec)	25.3±16.5	32.4±21.5	35.4±18.7	18.3	<0.001*	0.009α	<0.001α	0.802α
Right lateral muscular test (sec)	22.3±14.1	31.0±14.8	33.8±17.3	31.6	<0.001*	<0.001α	<0.001α	0.995α
Prone bridge test (sec)	23.4±14.9	30.5±20.2	36.5±20.0	26.2	<0.001*	0.066α	<0.001α	0.021α
Supine bridge test (sec)	128.9±102.1	176.7±131.9	169.6±122.8	28.3	<0.001*	<0.001α	<0.001α	0.716α
Transversus abdominis prone test (mmHg)	7.7±3.1	8.9±2.8	9.5±2.3	17.8	<0.001*	0.381α	0.002α	0.157α

p: Statistical tests: Friedman test; pα: Dunn Test; W0-W3: Baseline-week 3; W0-W8: Baseline-week 8, W3-W8: Week 3-week 8. X²: chi-square; SD: Standard deviation; sec: second

TABLE 4: Leg lowering test results at baseline, 3rd week, and 8th week

Leg lowering test (angle)	Baseline (W0) %	Week 3 (W3) %	Week 8 (W8) %	p*	pα (W0-W3)	pα (W0-W8)	pα (W3-W8)
90-75°	96.2%	61.5%	46.2%	<0.001*	0.184α	0.021α	0.405α
75-60°	3.8%	38.5%	53.8%	<0.001*	0.184α	0.021α	0.405α

p: Friedman test; pα: Dunn test; %: Percentage; W0-W3: Baseline-week 3; W0-W8: Baseline-week 8, W3-W8: Week 3-week 8

TABLE 5: Hip muscle strength at baseline, 3rd week, and 8th week

Parameter	Baseline (W0) X̄±SD	Week 3 (W3) X̄±SD	Week 8 (W8) X̄±SD	X²	p*	pα (W0-W3)	pα (W0-W8)	pα (W3-W8)
Right hip flexor (kg)	24.9±7.6	27.1±6.5	28.4±8.0	19.7	<0.001*	0.113α	<0.001α	0.066α
Left hip flexor (kg)	25.2±6.9	27.7±6.5	29.7±7.8	20.8	<0.001*	0.436α	<0.001α	0.011α
Right hip extensor (kg)	20.0±5.7	24.2±6.5	25.7±5.7	29.6	<0.001*	0.001α	<0.001α	0.288α
Left hip extensor (kg)	21.2±5.7	23.7±6.1	25.8±6.6	33.9	<0.001*	0.007α	<0.001α	0.716α
Right hip abductor (kg)	22.0±7.3	26.8±7.4	28.3±8.2	28.9	<0.001*	<0.001α	<0.001α	0.367α
Left hip abductor (kg)	22.1±6.9	25.9±7.1	28.1±7.8	19.8	<0.001*	0.008α	<0.001α	0.008α
Right hip adductor (kg)	18.2±5.9	21.8±7.2	23.3±6.7	27.9	<0.001*	0.009α	<0.001α	0.095α
Left hip adductor (kg)	18.6±6.9	22.4±8.8	23.4±7.7	21.3	<0.001*	0.017α	<0.001α	0.249α
Right hip internal rotator (kg)	14.1±4.3	16.3±5.3	17.0±6.8	8.1	0.018*	0.038α	0.066α	0.835α
Left hip internal rotator (kg)	14.3±4.2	15.9±4.6	17.4±5.1	23.2	<0.001*	0.046α	<0.001α	0.080α
Right hip external rotator (kg)	12.1±3.7	14.7±4.7	14.8±5.1	9.9	0.007*	0.031α	0.025α	0.095α
Left hip external rotator (kg)	11.6±3.6	12.7±3.7	13.7±5.3	6.0	0.049*	0.214	0.95	0.729

X²: chi-square; SD: Standard deviation; kg: Kilogram; p: Statistical tests: Friedman test; pα: Dunn test; W0-W3: Baseline-week 3, W0-W8: Baseline-week 8; W3-W8: Week 3-week 8

compared to the general exercise group.[23] Our study found a significant improvement in VAS motion and VAS rest evaluation at week 8 compared to pretreatment VAS, while only VAS motion showed significant improvement at week 3. Although there was a decrease in VAS night score compared to pretreatment, it was not statistically significant.

Coulombe et al. conducted a meta-analysis to compare general low back exercises with stabilization exercises.[24] They found that core exercises were superior to general exercises in improving pain scores and functional scores at 3 months. However, no difference was observed at 6 months.[24]

Alp et al. conducted a study on 48 female patients with chronic LBP to compare the effectiveness of home exercise programs and stabilization exercises.[25] The stabilization group showed improvement at VAS, RM scores, SF-36 (Short Form-36) and Sorensen test measuring lumbar extensor endurance after exercise, while the home exercise group showed improvement in all parameters except for Sorensen test and SF-36 pain and social function scores. When comparing the groups, the stabilization group was superior to the home exercise group in terms of the Sorensen test and SF-36 physical function limitation scores.[25] Kapetanovic et al. found that core stabilization exercises were effective in improving functional status in individuals with LBP.[26] Stankovic et al. studied the effectiveness of lumbar stabilization exercises in addition to stretching and strengthening exercises in improving function and pain in individuals with LBP and found a significant improvement in the ODI Questionnaire in the stabilization group compared to the control group.[27] In our study, in line with the current literature, there was a significant improvement in the ODI and RM scores at week 8 compared with pretreatment.

Ferreira et al. assessed TA activation using ultrasound in individuals with chronic LBP and found a significant increase in TA activity in the core stabilization exercise group compared with the general exercise and spinal manipulation groups after treatment.[28] França et al. compared the effects of stabilization exercises and trunk and hamstring stretching exercises on pain, disability, and TA activation in people with chronic LBP.[29] Both exercises reduced pain and disability, but stabilization exercises were effective in increasing TA activation while stretching exercises were ineffective.[29] The TA prone test, which was used to assess TA activation in our study, showed a significant increase in TA activation at the end of week 8 compared to the pre-exercise period. In our study, the TA prone test used to evaluate TA activation, in accordance with the literature, showed a significant increase in TA activation at the end of the 8th week compared to the pre-exercise period.

Abdelraouf et al. found that core strength was lower in young athletes with LBP than in those without.[30] In a study by Desai et al. involving 100 volunteers with LBP and 100 volunteers without LBP, the prone bridge test was performed in both groups.[31] It was found that the duration of the test was significantly shorter in the group with LBP compared to those without LBP. In our study, there was a significant increase in the test duration values at week 8 for the flexor endurance test, the supine and prone bridge test, and the left and right lateral muscular test, which were among the tests performed to assess the endurance of the trunk core muscles, compared to the baseline values.

Cooper et al.[32] found that hip musclestrength was reduced in people with LBP compared to healthy people. Narouei et al. found that core exercises in patients with chronic nonspecific LBP increased the gluteus maximus muscle thickness of these patients after 4 weeks.[33] Our study similarly found a significant increase in hip muscle strength at week 8, except for left hip external rotation and right hip internal rotation.

Our study had some limitations. Due to the short follow-up period, the long-term effectiveness of lumbar stabilization exercises was limited. In addition, the small number of patients and the lack of a control group are other limitations of the study. However, one of the strengths of our study is that it assessed the effectiveness of core stabilization exercises on all parameters including pain, functionality, hip muscle strength, and core endurance in patients with chronic LBP. Other strengths of the study include its prospective design and the fact that patients were assessed

using objective tests such as the prone bridge test, supine bridge test, flexion endurance test, lateral muscle test, prone transversus abdominis test, and hip muscle strength assessment using a dynamometer.

CONCLUSION

It should be noted that lumbar stabilization exercises increase trunk endurance and muscle strength and are effective on pain and function in patients with chronic nonspecific LBP. Further studies with larger numbers of patients are needed.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

REFERENCES

1. Sergent JS, Budd RC, Ruddy S, et al. Low back pain. In: Firestein GS, Harris ED, eds. Firestein&Kelley's Textbook of Rheumatology. 8th ed. Philadelphia: Elsevier; 2008. p.617-25.
2. Cassidy JD, Carroll LJ, Côté P. The Saskatchewan health and back pain survey. The prevalence of low back pain and related disability in Saskatchewan adults. Spine (Phila Pa 1976). 1998;23:1860-6; discussion 1867. PMID: 9762743.
3. Maher C, Underwood M, Buchbinder R. Non-specific low back pain. Lancet. 2017;389:736-47. PMID: 27745712.
4. Manchikanti L. Epidemiology of low back pain. Pain Physician. 2000;3:167-92. PMID: 16906196.
5. Krismer M, van Tulder M. Low back pain (non-specific). Best Practice & Research Clinical Rheumatology. 2007;21:77-91. https://doi.org/10.1016/j.berh.2006.08.004
6. Oliveira CB, Maher CG, Pinto RZ, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care:an updated overview. Eur Spine J. 2018;27:2791-803. PMID: 29971708.
7. Corp N, Mansell G, Stynes S, et al. Evidence-based treatment recommendations for neck and low back pain across Europe: a systematic review of guidelines. Eur J Pain. 2021;25:275-95. PMID: 33064878; PMCID: PMC7839780.
8. Zhou T, Salman D, McGregor AH. Recent clinical practice guidelines for the management of low back pain: a global comparison. BMC Musculoskelet Disord. 2024;25:344. PMID: 38693474; PMCID: PMC11061926.
9. Hayden JA, van Tulder MW, Malmivaara A, et al. Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev. 2005;2005:CD000335. PMID: 16034851; PMCID: PMC10068907.
10. Hayden JA, van Tulder MW, Tomlinson G. Systematic review: strategies for using exercise therapy to improve outcomes in chronic low back pain. Ann Intern Med. 2005;142:776-85. PMID: 15867410.
11. Vleeming A, Schuenke MD, Danneels L, et al. The functional coupling of the deep abdominal and paraspinal muscles: the effects of simulated paraspinal muscle contraction on force transfer to the middle and posterior layer of the thoracolumbar fascia. J Anat. 2014;225:447-62. PMID: 25139243; PMCID: PMC4174027.
12. Ayşegül Ketenci NŞ, Bekir Durmuş. Terapötik Egzersizler 1: Servikal ve Lomber Omurga Egzersizleri. 1. Baskı. İstanbul: Akademi Yayınları; 2014.
13. Moon JH, Hong SM, Kim CW, et al. Comparison of deep and superficial abdominal muscle activity between experienced pilates and resistance exercise instructors and controls during stabilization exercise. J Exerc Rehabil. 2015;11:161-8. PMID: 26171383; PMCID: PMC4492427.
14. Akuthota V, Ferreiro A, Moore T, et al. Core stability exercise principles. Curr Sports Med Rep. 2008;7:39-44. PMID: 18296944.
15. Dülger E, Bilgin S, Bulut E, et al. The effect of stabilization exercises on diaphragm muscle thickness and movement in women with low back pain. J Back Musculoskelet Rehabil. 2018;31:323-9. PMID: 29278870.
16. Price DD, McGrath PA, Rafii A, et al. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain. 1983;17:45-56. PMID: 6226917.
17. Yakut E, Düger T, Oksüz C, et al. Validation of the Turkish version of the Oswestry Disability Index for patients with low back pain. Spine (Phila Pa 1976). 2004;29:581-5; discussion 585. PMID: 15129077.
18. Küçükdeveci AA, Tennant A, Elhan AH, et al. Validation of the Turkish version of the Roland-Morris Disability Questionnaire for use in low back pain. Spine (Phila Pa 1976). 2001;26:2738-43. PMID: 11740366.
19. Sutton M. Musculoskeletal interventions: techniques for therapeutic exercise. Physiother Can. 2010;62:166. PMCID: PMC2871028.
20. Richardson CA, Hodges P, Hides JA. Therapeutic Exercise for Lumbopelvic Stabilization: A Motor Control Approach for the Treatment and Prevention of Low Back Pain. 2nd ed. London: Churchill Livingstone; 2004.
21. Brumitt J, Matheson JW, Meira EP. Core stabilization exercise prescription, part I: current concepts in assessment and intervention. Sports Health. 2013;5:504-9. PMID: 24427424; PMCID: PMC3806181.
22. Krause DA, Neuger MD, Lambert KA, et al. Effects of examiner strength on reliability of hip-strength testing using a handheld dynamometer. J Sport Rehabil. 2014;23:56-64. PMID: 24231811.
23. Akhtar MW, Karimi H, Gilani SA. Effectiveness of core stabilization exercises and routine exercise therapy in management of pain in chronic non-specific low back pain: A randomized controlled clinical trial. Pak J Med Sci. 2017;33:1002-6. PMID: 29067082; PMCID: PMC5648929.
24. Coulombe BJ, Games KE, Neil ER, et al. Core stability exercise versus general exercise for chronic low back pain. J Athl Train. 2017;52:71-2. PMID: 27849389; PMCID: PMC5293521.
25. Alp A. Efficacy of core-stabilization exercise and its comparison with home-based conventional exercise in low back pain patients. Turk J Phys Med Rehab. 60:36-42. doi: 10.5152/tftrd.2014.26817

26. Kapetanovic A, Jerkovic S, Avdic D. Effect of core stabilization exercises on functionaldisability in patients with chronic low back pain. Journal of Health Sciences. 2016;6:59-66. https://www.jhsci.ba/ojs/index.php/jhsci/article/view/537/547

27. Stankovic A. Lazovic M, Kocic M. Lumbar stabilization exercises in addition to strengtheningand stretching exercises reduce pain and increase functionin patients with chronic low back pain: randomized clinicalopen-label study. Turk J Phys Med Re hab. 2012;58:177-83. doi : 10.4274/tftr.22438

28. Ferreira PH, Ferreira ML, Maher CG, et al. Changes in recruitment of transversus abdominis correlate with disability in people with chronic low back pain. Br J Sports Med. 2010;44:1166-72. PMID: 19474006.

29. França FR, Burke TN, Caffaro RR, et al. Effects of muscular stretching and segmental stabilization on functional disability and pain in patients with chronic low back pain: a randomized, controlled trial. J Manipulative Physiol Ther. 2012;35:279-85. PMID: 22632587.

30. Abdelraouf OR, Abdel-Aziem AA. The relationship between core endurance and back dysfunction in collegiate male athletes with and without nonspecific low back pain. Int J Sports Phys Ther. 2016;11:337-44. PMID: 27274419; PMCID: PMC4886801.

31. Desai D. Effect of Low Back Pain on Anterior Core Muscle Endurance in College Aged Individuals. International Journal of Health Sciences and Research. 2018;8:116-21. https://www.ijhsr.org/IJHSR_Vol.8_Issue.1_Jan2018/17.pdf

32. Cooper NA, Scavo KM, Strickland KJ, et al. Prevalence of gluteus medius weakness in people with chronic low back pain compared to healthy controls. Eur Spine J. 2016;25:1258-65. PMID: 26006705.

33. Narouei S, Barati AH, Akuzawa H, et al. Effects of core stabilization exercises on thickness and activity of trunk and hip muscles in subjects with nonspecific chronic low back pain. J Bodyw Mov Ther. 2020;24:138-46. PMID: 33218502.