

Research Paper

Effects of Core Stabilization on Lumbopelvic Motor Control and Pain in Patients with Nonspecific Chronic Low Back Pain: A Randomized Clinical Pilot Study



Hossein Shahrokhi^{1*}, Mohammad Fallah Mohammadi², Aynollah Naderi³, Zahra Nabizadeh²

1. Department of Sports Injuries and Corrective Exercise, Faculty of Sports Sciences, Hakim Sabzevari University, Sabzevar, Iran.
2. Department of Sports Sciences, School of Humanities, Shafagh Institute of Higher Education, Mazandaran, Iran.
3. Department of Health and Exercise Sciences, School of Sport Sciences, Shahrood University of Technology, Shahrood, Semnan, Iran.



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ABSTRACT



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Aims Pain and altered motor control are consequences of chronic low back pain (LBP). The present study aimed to assess the effects of a six-week Swiss ball core stabilization program on pain levels and lumbopelvic motor control in patients suffering from nonspecific LBP.

Materials & Methods This randomized clinical pilot study involved 24 participants (12 females and 12 males) who were diagnosed with nonspecific chronic LBP (mean age=42.08±7.05 years). Participants were randomly assigned to two groups: experimental (n=12) and control (n=12). The experimental group underwent a six-week intervention of core stability exercises, while the control group received routine physical therapy. The primary outcome measured was pain intensity using a visual analog scale ranging from 0-10. Secondary outcomes included lumbopelvic motor control, which was assessed using various tests, such as the knee lift abdominal test, bent knee fall-out test, Waiter's Bow test, sitting knee extension test, and transversus abdominis test. Evaluations were conducted at three time points: baseline, the end of a six-week intervention, and after one month of follow-up.

Findings The core intervention resulted in a significant increase in motor control during the post-test ($P<.001$; Cohen's $d=6.04$), although this effect did not persist in the follow-up assessment. Moreover, a significant decrease in pain intensity was observed both during the post-test ($P<.001$; Cohen's $d=3.31$) and follow-up ($P<.001$; Cohen's $d=2.98$) periods. Furthermore, significant differences were identified between the two groups in all outcome measures following the intervention ($P<.05$).

Conclusion Compared to routine physical therapy, the six-week core stability exercises on the Swiss ball resulted in marked improvements in pain intensity and lumbopelvic motor control in patients with nonspecific chronic LBP.

Keywords:

Back pain,
Exercise,
Motor control,
Physical therapy

* Corresponding Author:

Hossein Shahrokhi, PhD.

Address: Department of Sports Injuries and Corrective Exercise, Faculty of Sports Sciences, Hakim Sabzevari University, Sabzevar, Iran.

Tel: +98 9124596240

E-mail: h.shahrokhi@hsu.ac.ir



مقاله پژوهشی

تأثیر تثبیت مرکز بدن در کنترل حرکت کمری لگنی و درد کمر در بیماران مبتلا به کمردرد مزمن غیراختصاصی: یک مطالعه کارآزمایی بالینی تصادفی

حسین شاهرخی^{۱*}، محمد فلاح محمدی^۲، عین‌اله نادری^۳، زهرا نبی‌زاده^۲

۱. گروه آسیب شناسی ورزشی و حرکات اصلاحی، دانشکده ی علوم ورزشی، دانشگاه حکیم سبزواری، سبزوار، ایران.

۲. گروه علوم ورزشی، دانشکده ی علوم انسانی، مؤسسه ی آموزش عالی شفق، مازندران، ایران.

۳. گروه علوم ورزشی، دانشکده ی تربیت بدنی و علوم ورزشی، دانشگاه صنعتی شاهرود، شاهرود، سمنان، ایران.

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چکیده

تاریخ دریافت: ۱۴۰۲/۰۸/۲۲

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هدف: درد و تغییر در کنترل حرکتی از پیامدهای کمردرد مزمن است. مطالعه‌ی حاضر به منظور بررسی تأثیر برنامه‌ی شش‌هفته‌ای تثبیت‌کننده‌ی مرکز بدن روی توپ سوئیسی در سطح درد و کنترل حرکتی کمری لگنی در بیماران مبتلا به کمردرد مزمن غیراختصاصی انجام شد.

مواد و روش‌ها این مطالعه‌ی کارآزمایی بالینی تصادفی‌شده درباره‌ی ۲۴ شرکت‌کننده‌ی مبتلا به کمردرد مزمن غیراختصاصی (۱۲ زن و ۱۲ مرد؛ میانگین [SD] سن=۴۲/۰۸ [۷/۰۵] سال) بود. شرکت‌کنندگان به‌طور تصادفی در دو گروه آزمایش (n=۱۲) و کنترل (n=۱۲) قرار گرفتند. افراد گروه آزمایش تحت یک مداخله‌ی شش‌هفته‌ای تمرینات ثبات مرکزی روی توپ سوئیسی قرار گرفتند، درحالی‌که افراد گروه کنترل فیزیوتراپی روتین دریافت کردند. شدت درد پیامد اولیه‌ی اندازه‌گیری‌شده و کنترل حرکتی پیامد ثانویه بود. پیامد اولیه شدت درد بود که با استفاده از مقیاس آنالوگ بصری از ۰ تا ۱۰ اندازه‌گیری شد. پیامد ثانویه کنترل حرکتی کمری لگنی بود که با استفاده از تست‌های مختلف مانند تست شکمی بلند کردن زانو، تست افتادن زانو به خارج زانوی خم، تست تعظیم پیشخدمت، تست اکستنشن زانوی نشسته و تست عضلات عرضی شکم ارزیابی شد. ارزیابی‌ها در پیش‌آزمون، در انتهای مداخله و در پیگیری یک‌ماهه صورت گرفت.

یافته‌ها مداخله‌ی اصلی به افزایش معنادار کنترل حرکتی در پس‌آزمون منجر شد ($d=۶/۰۴$, $P>۰/۰۰۱$)، اگرچه این اثر در ارزیابی پیگیری ادامه پیدا نکرد. علاوه بر این، کاهش معناداری در شدت درد هم در دوره‌ی پس‌آزمون ($d=۳/۳۱$, $P>۰/۰۰۱$) هم در دوره‌ی پیگیری ($d=۲/۹۸$, $P>۰/۰۰۱$) مشاهده شد. علاوه بر این، در هر دو گروه بین میانگین هر دو متغیر از پیش‌آزمون تا پس‌آزمون تفاوت معناداری مشاهده شد ($P>۰/۰۵$).

نتیجه‌گیری شش هفته تمرینات ثبات مرکزی روی توپ سوئیسی در مقایسه با فیزیوتراپی روتین به بهبود بیشتر شدت درد و کنترل حرکتی کمری لگنی در بیماران مبتلا به کمردرد مزمن غیراختصاصی منجر شد.

کلیدواژه‌ها:

تمرین،
کمردرد،
کنترل حرکتی،
فیزیوتراپی

* نویسنده مسئول:

حسین شاهرخی

نشانی: گروه آسیب شناسی ورزشی و حرکات اصلاحی، دانشکده ی علوم ورزشی، دانشگاه حکیم سبزواری، سبزوار، ایران.

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پست الکترونیکی: h.shahrokhi@hsu.ac.ir

Introduction

Low back pain (LBP) is a common musculoskeletal disorder experienced by 70%-80% of people in their lifetime [1]. Approximately 5%-10% of patients develop chronic back pain, leading to high healthcare costs, productivity loss, and individual disability [2]. LBP is a major contributor to global disability and ranks sixth in overall burden [3]. Often nonspecific, LBP lacks a specific underlying cause but can lead to various complications, such as increased trunk force variability, body stiffness, and reduced movement variability in the lower limbs [4, 5]. These complications contribute to impaired trunk muscle control, increased oscillation of the center of pressure and mass, changes in body position, decreased nerve conduction velocity, and increased thigh and trunk movements [6]. In addition, the condition can be worsened by disuse atrophy and decreased muscle strength [7].

The economic burden of LBP is substantial, with annual direct costs ranging from €2.3 billion to €2.6 billion and indirect costs between €0.24 billion and \$8.15 billion in high-income countries. The pooled annual hospitalization rate for LBP is 3.2%, with per-patient direct costs averaging USD 9,231 and total costs around USD 10,143. These figures underscore the extensive financial impact of LBP, highlighting the need for effective management and prevention strategies [8].

Evidence-based research has demonstrated that therapeutic exercise is a widely recommended and effective treatment for LBP, either on its own or in combination with other therapies [9, 10, 11]. In recent years, there has been a growing recognition of the significance of core stability due to studies indicating that patients with LBP experience delayed or reduced activation of specific muscles, leading to a compromised support system for the lumbar spine and an increased burden on its joints and ligaments, potentially resulting in more stress and strain [12]. Core stabilization exercises have been recognized for their positive impact on the strength, endurance, and flexibility of spine muscles, as well as their ability to train stabilizing muscles involved in movement, promoting control and stability in the lower back [13]. Moreover, core stabilization exercises improve the feed-forward mechanism during peripheral limb movements, thereby ensuring lumbopelvic motor control and stability [4]. Nevertheless, there is ongoing debate regarding whether core exercises are more effective than general exercise for lower back pain [14, 15].

It is crucial to have a thorough understanding of the potential benefits of core stabilization exercises for chronic nonspecific lower back pain [16]. One common

type of recommended exercise involves unstable surfaces, although specific reasons and the overall effectiveness of this approach remain unclear. Some studies have been conducted in this field so far. For instance, Young et al. (2015) compared the effectiveness of proprioceptive neuromuscular facilitation integration patterns and Swiss ball training on balance and pain in elderly patients with chronic low back pain [17]. The researchers reported that the proprioceptive neuromuscular facilitation integration pattern was superior to Swiss ball exercises in the improvement of balance; nonetheless, they found no significant differences in functional tests and pain intensity results [17].

Given the close link between pain and motor control in LBP patients, it seems helpful to assess the effect of core exercise on both of these variables [18]. Yet, this effect is not well-studied among patients with chronic nonspecific LBP [19]. Motor re-education is of utmost importance in addressing the causes of LBP, specifically alterations in muscle recruitment patterns and impaired trunk muscle movement [20]. Core exercises on a Swiss ball have been demonstrated to induce neuroplastic changes in the nervous system, leading to improved muscle activity and trunk muscle recruitment for spinal stabilization [21, 22]. Furthermore, it has been revealed that exercising on Swiss balls is enjoyable and motivating for individuals [20, 23]. Given the significant impact of chronic LBP on motor control, core stabilization using a Swiss ball could be a beneficial training approach for enhancing motor control and reducing pain in these patients [20, 23].

Research in the field of Swiss ball core stabilization exercises for chronic nonspecific LBP is essential due to the significant prevalence and impact of LBP globally, ranking as the sixth leading cause of disability [2]. Chronic LBP not only imposes a substantial economic burden but also results in individual disability and decreased quality of life [3, 24]. Despite the availability of various treatment options, there remains a need for effective strategies to address the complexities of LBP, including impaired trunk muscle control and increased body stiffness [1]. The present research sought to bridge the existing gaps by explicitly investigating the efficacy of Swiss ball exercises in alleviating pain and improving motor control in patients with chronic nonspecific LBP. An improved understanding of these interventions enables us to potentially enhance patient outcomes, reduce healthcare costs, and alleviate the overall burden of LBP on individuals and society.

The present study aimed to assess the impact of Swiss ball core stabilization on the amount of pain and motor control in the lumbar region of patients with chronic

nonspecific LBP and its persistence in a one-month follow-up.

Materials and Methods

Study design and participants

This randomized clinical trial (IRCT20200107046035N5) employed pre-test, post-test, and follow-up assessments. The study included 24 participants with nonspecific chronic LBP, comprising 12 females and 12 males, with a mean age of 42.08 ± 7.05 years. G*Power3.1 software was utilized to determine a sample size of 12 participants in each group for the study, considering an effect size (d) of 0.50 based on a previous study[25], significance level (α) two-tailed set at .05, and a desired power ($1-\beta$) of .80.

The inclusion criteria entailed participants aged 30-50 with chronic nonspecific LBP lasting at least three months and an Oswestry Disability Index above 16%. These individuals were required to be referred to an orthopedist. On the other hand, the exclusion criteria were as follows: acute LBP, spinal stenosis or surgery, inflammatory disease affecting the spine, fracture, spondylolysis or spondylolisthesis, use of relevant medication, symptoms associated with specific LBP lumbopelvic surgery, lower limb, and abdominal

surgery in the past three months, and prior core stability training or athletic experience[24]. This study obtained approval from the Institution Review Board (IR.SSRC.REC.1399.076), and all participants provided informed consent.

Randomization

Participants meeting inclusion criteria were enrolled by an independent and blinded researcher. Random allocation to the experimental or control group was determined by a computer-generated sequence, employing a block size of 2, 4, 6, and an allocation ratio of 1:1. Group assignments were concealed in sealed envelopes opened after participants completed baseline assessments. Participants were randomly assigned to the experimental or control group (block size of 2, 4, 6 allocation ratio 1:1), as depicted in Figure 1. Demographic information was collected, and data were gathered before and after six weeks of core stability exercises for the training group, with a one-month follow-up. A laboratory specialist, not directly involved in the study and blinded to the interventions, performed the clinical assessments. The data analysts were blinded to group allocation. Participants were instructed not to reveal or discuss treatment with the evaluator.

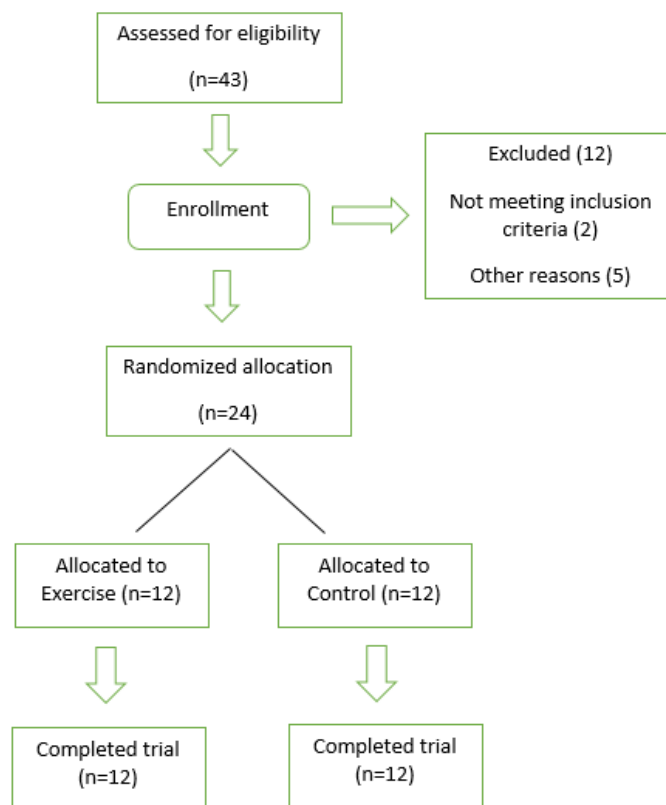


Figure 1. Flowchart of subject recruitment and allocation

Outcome measures

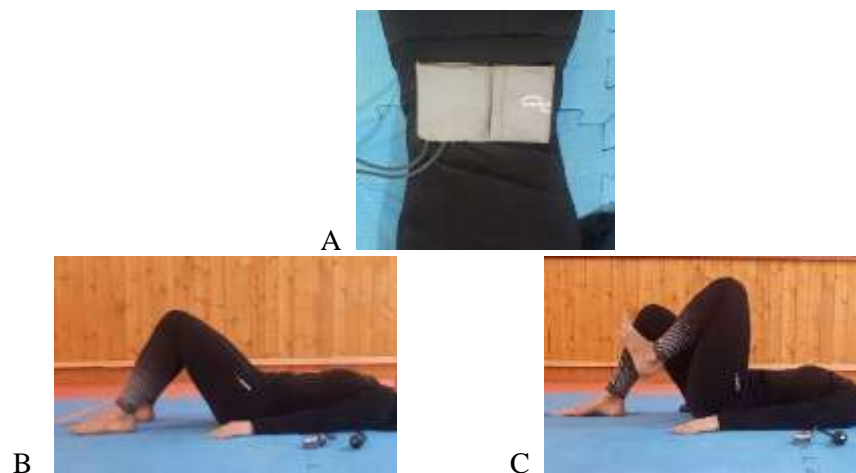
Measurements were taken at three time points: baseline, the end of a six-week intervention, and after one month of follow-up. The primary outcome measured was pain intensity using a visual analog scale (VAS) ranging from 0-10. Secondary outcomes included lumbopelvic motor control, which was assessed using various tests, such as the knee lift abdominal test, bent knee fall-out test, waiter's bow test, sitting knee extension test, and transversus abdominis test. Acceptable reliability is demonstrated for this test battery [26, 27]. Further details about these outcome measures are presented in Table 1.

Pain Measurement: VAS measures the pain of patients subjectively. This scale is a 10-centimeter line, and patients are asked to grade their pain condition from 0 (no pain) to 10 (extreme amount of pain). The validity

and reliability of this instrument have been reported to be very high [28].

Lumbopelvic Motor Control Measurement: The following tests were administered to assess lumbopelvic motor control, ensuring no order effects by randomization and incorporating one-minute breaks between each test. Participants completed three familiarization trials before each test.

Knee lifts abdominal test: The participant was lying on their back with their arms at their sides and feet on the floor. They were administered a test by gently raising their leg while holding the pelvis, lumbar spine, and knee in a flexed position until the hip reached a 90-degree flexion. Pressure changes were measured using a horizontally placed pressure biofeedback unit under the spine, near the posterior superior iliac spine. The test was repeated twice for each participant, and the average results were measured (Figure 2) [7].



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Figure 2. Knee lifts abdominal test: (A) Position of the pressure biofeedback unit, (B) Start position for the test, and (C) Test movement

Bent knee fall-out test: The participant was lying on their back with one hip flexed and the other leg fully extended. Two pressure biofeedback units were placed vertically under the lumbar spine. The units were inflated to a baseline pressure of 40 mm Hg. The participant performed two breathing cycles, and the pressure was then adjusted back to 40 mm Hg. They were instructed to maintain a neutral spine position while slowly rotating the extended leg outward by 45 degrees for a few seconds without moving the foot, pelvis, or lumbar spine. The maximum pressure deviation was recorded for analysis. This test was repeated twice for each participant, and the average was calculated [7].

Waiter bow test: Participants stood upright and were instructed to bend their trunk 50 degrees from the hip joint without any movement in the lumbar spine. The examiner visually assessed their ability to stabilize the

trunk through isometric activity and maintain a neutral spine position. A score of one was given if the participant demonstrated trunk muscle activation and maintained a neutral spine position during the test. A score of zero was allocated if they were unable to do so. The test was repeated twice for each participant, and the average score was recorded [7].

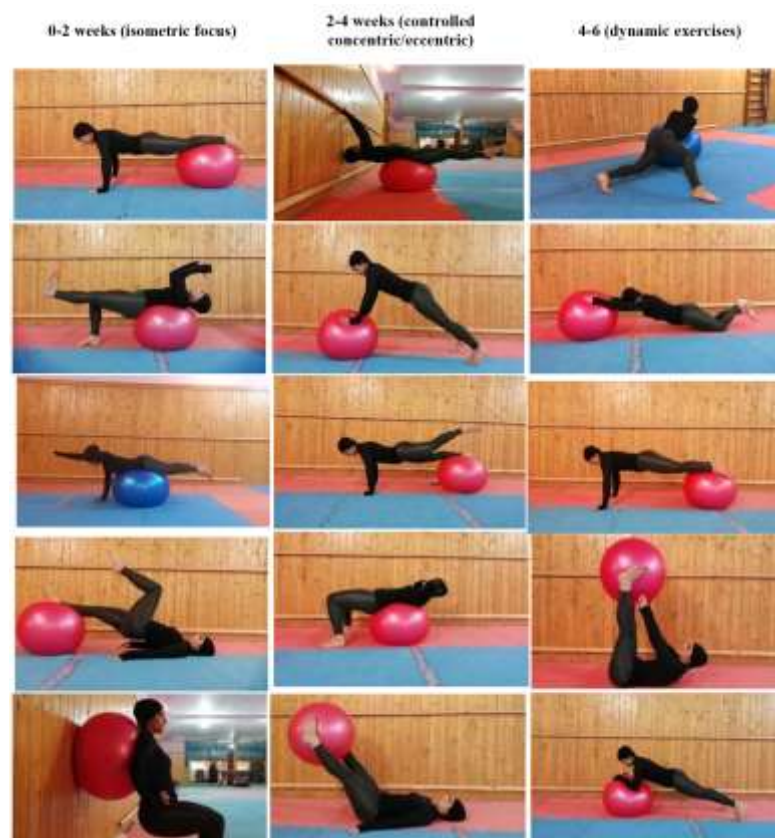
Sitting knee extension test: Participants were seated with a neutral pelvic tilt. They were instructed to extend their knee while keeping their lumbar spine in a neutral position. The examiner visually assessed their ability to stabilize the trunk through isometric activity and maintain a neutral spine position. A score of one was given if the participant demonstrated trunk muscle activation and maintained a neutral spine position during knee extension. The test was repeated twice for each participant, and the average score was recorded [7].

Transversus abdominis test: Participants were positioned in a supine position with relaxed arms, feet flat on the floor, and knees bent at a 90-degree angle. The examiner assessed the contraction ability of the transversus abdominis muscle through observation and palpation. By placing their thumb around two centimeters inward and downward from the protrusion of the anterior superior iliac spine, the examiner asked participants to draw in their abdominal wall for 10 sec without moving their spine inward. A failed test, resulting in a zero score, was noted if there was spinal movement, bulging of the abdominal wall, inability to contract transversus abdominis muscle, or inability to sustain the contraction for ten seconds. A score of one was assigned if the contraction was maintained without spinal movement. The test was repeated twice for each participant, and the average score was recorded [7]. Reliability for assessing transversus abdominis recruitment by manual palpation is reported to be acceptable [26]. After conducting five tests, each patient's movement control score ranged from zero (failure in all five tests) to five (success in all five tests). The final motor control score was determined by calculating the mean score of the participants' motor control [29].

Exercise intervention

The experimental group underwent a six-week core

stability exercise program using a Swiss ball. The regimen consisted of three sessions per week, each lasting approximately 50 min. Each session began with a 10-minute warm-up, followed by 35-45 minutes of the main core stability exercise program. The sessions concluded with a five-minute cool-down, during which participants performed stretching movements. Participants performed each exercise for 10 sec, repeating it 10 times with 1-minute rest intervals between exercises. They were verbally and visually guided by a trained coach throughout the protocol in a group setting. On the contrary, the control group received routine physical therapy treatment, including transcutaneous electrical nerve stimulation and hot pack application over the painful area of the lower back, for 30 min, three days a week, for six consecutive weeks. Both groups were instructed to avoid engagement in other physical activities or training during the study period. The exercise protocol followed in this study was a modified version of the core stability exercises with a Swiss ball developed by Marshall et al. (2008) for patients with chronic LBP, tailored to fit the six-week duration [30]. In the experimental group, participants were required to attend a minimum of 15 out of 18 training sessions to remain part of the study. Detailed illustrations of the exercise program are illustrated in Figure 3.



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Figure 3. Swiss ball exercise program

Statistical analyses

The SPSS software (version 21) was used for data analysis. Results are expressed as means±SD. Kolmogorov-Smirnov testing was conducted to determine if the data were normally distributed. In normally distributed variables (all variables), mixed repeated measures ANOVA, repeated-measures ANOVA, Bonferroni post hoc test, and the independent samples Student's t-test were employed. The significance level was set at 0.05. In addition, Cohen's d effect sizes were calculated to measure the magnitude of the difference. The values of <.2, .21-.49, .50 to .79, and ≥ .80 are considered trivial, small, moderate, and large effects, respectively [31]. In addition, Eta-squared (η²) was used as a measure of effect size in the ANOVA (η² around 0.01, 0.06, and 0.14 are considered small, medium, and large, respectively).

Results

A total of 24 participants were recruited in this study. Table 1 summarizes the comparison of age, weight, height, and body mass index (BMI) between the

experimental and control groups, including their means, standard deviations, and p-values. The mean scores of age, weight, height, and disability in experimental participants were reported as 43.08±5.10 years, 71.42±4.95 kg, 163.33±6.61 cm, and 51.41±7.82, respectively. Participants in the control group have an age of 41.08±8.71 years, weight of 73.17±4.89 kg, height of 160.91±5.96 cm, and disability of 53.66±4.90.

The group means for pain and motor control were measured at three time points: pre-test, post-test, and follow-up (Table 2). To analyze the data, a mixed repeated measures ANOVA (2*3) was used to examine within-group (pre-test, post-test, and follow-up) and between-group (experimental and control) factors. The results pointed to a significant interaction between group and time for pain and motor control variables (P< 0.001), as displayed in Table 2. Further analysis using independent t-tests revealed significant differences in pain values between the experimental and control groups at the post-test and follow-up (P<0.001). In addition, motor control values significantly differed between the two groups in the post-test (P<0.001) but not in the follow-up (P=0.055), as presented in Table 3.

Table 1. Comparison of demographic characteristics and body mass index between experimental and control groups

Variables	Experimental (n=12)	Control (n=12)	p-value
Age (year)	43.1±5.1	41.1 ±8.7	0.78
Weight (Kg)	71.4±4.9	73.2±4.9	0.66
High (Cm)	163.3±6.6	160.9±5.9	0.86
BMI (Kg/m ²)	26.8 ±2.84	28.3±2.81	0.69

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Table 2. Group means of experimental and control groups at pre-test, post-test, and follow-up for pain and motor control

Groups	Pre-test	Post-test	Follow-up	Time effects			Group effects			Interaction effects			
				f	p	Eta	f	p	Eta	f	p	Eta	
Pain (0-10 mm)	Experimental	49.73±4.68	32.24±6.45	34.36±5.58	46.5	<.001	0.67	70.8	<.001	.76	34.5	<.001	.61
	Control	51.25±2.56	50.35±3.57	49.43±2.87									
Motor Control (0-0 point)	Experimental	1.77±0.22	3.50±0.34	1.86±0.29	99.4	<.001	0.81	120.51	<.001	.84	34.3	<.001	.61
	Control	1.66±0.18	1.81±0.26	1.65±0.21									

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Table 3. Summary of independent t-test results

	Pre-test				Post-test				Follow-up			
	Mean Difference	t	p	Cohen's d	Mean Difference	t	p	Cohen's d	Mean Difference	t	p	Cohen's d
Pain	1.51	.98	.33	.47	18.1*	8.49	<.001	3.70	15.07*	8.31	<.001	3.36
Motor Control	.11	1.34	.19	.54	1.68*	13.44	<.001	5.58	.21	2.02	.055	.82

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* Significant difference (P<.01)

On the other hand, repeated-measures ANOVA results demonstrated that pain and motor control had significant differences between the pre-test, post-test, and follow-up phases in the experimental group (P<0.001). Therefore, the Bonferroni post-hoc test was utilized for separate comparisons (pre-test, post-test, and follow-

up). The Bonferroni post-hoc test findings indicated significant differences between pre-test and post-test, and between pre-test and follow-up for pain values (P< 0.001). However, the difference between post-test and follow-up was not statistically significant (P=0.172) (Table 4).

Table 4. Summary of the repeated-measures ANOVA and the Bonferroni posthoc test results for pain and motor control in pre-test, post-test, and follow-up

	F	p		Mean Difference	p	Cohen's d
Pain	56.21	<.001	Pre-test – post-test	17.48*	<.001	3.31
			Pre-test – follow-up	15.37*	<.001	2.98
			Post-test – follow-up	2.11	.172	.55
Motor Control	141.66	<.001	Pre-test – post-test	1.72*	<.001	6.04
			Pre-test – follow-up	.09	1.00	.34
			Post-test – follow-up	1.63*	<.001	5.19

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* Significant difference ($P < .01$).

Discussion

This study is one of the few investigating the impact of Swiss ball core stabilization on pain and motor control in individuals with nonspecific chronic LBP. The findings demonstrated a significant reduction in pain intensity after core stability exercises on a Swiss ball, and the benefits persist during follow-up. Other studies comparing core stabilization programs with routine physical therapy or Pilates exercises also support the positive effects on muscle activity, thickness, pain, and disability in chronic LBP patients, indicating the potential efficacy of these interventions [32, 33].

The present study revealed a significant difference in motor control between the two groups following core stability exercises, though this effect was not sustained one month post-intervention. Consistent with these findings, Eliks et al. (2019) observed that Pilates-based exercises can enhance motor control quality in chronic nonspecific LBP [18]. Wang et al. (2023) compared postural control and core stability exercises in chronic LBP patients, reporting that both protocols induced balance improvements potentially linked to enhanced motor control of deep trunk muscles [20]. Park et al. (2016) and Mendis et al. (2016) corroborated that motor control exercises in the lumbopelvic region could improve muscle recruitment patterns and motor control, aligning with the results of the present study [19, 21]. On the contrary, Boucher et al. (2016) reported that stabilizing exercises in their study failed to achieve sensory-rich improvement in LBP patients [23], suggesting that the exercises employed were not specifically designed to enhance lumbar proprioception.

Core stability exercises enhance motor control in the lumbopelvic region through targeted engagement of muscles responsible for spinal and pelvic stability, promoting increased strength and endurance [19]. These exercises focus on key muscles, such as transversus abdominis and multifidus, addressing imbalances commonly associated with such conditions as LBP [34]. By specifically activating these muscles, core stability

exercises improve neuromuscular control and counteract abnormal muscle activity patterns seen in LBP, where mobilizing muscles, such as abdominal muscles, are overactive, while stabilizing muscles, such as multifidus, are underactive [34]. The exercises work to reverse selective atrophy, particularly in type II muscle fibers of multifidus, ultimately improving muscle fiber size [35, 36]. This reversal process helps restore balance between agonist and stabilizing muscles [37], leading to more coordinated movement patterns and, consequently, enhanced motor control in the lumbopelvic region. In addition, these exercises contribute to proprioceptive development, heightening the body's awareness of its position and movement [20]. This increased proprioception can result in more precise and controlled movements in the lumbopelvic region. Overall, the emphasis on core stability leads to improved muscle recruitment patterns, enhanced stability, and superior motor control, offering therapeutic benefits for individuals with LBP [32].

Core stability exercises have been demonstrated to effectively enhance neuromuscular control mechanisms in individuals with nonspecific chronic low back pain, potentially by improving sensory and motor control of the trunk and core muscles [38]. These exercises not only contribute to the development of trunk stability but also reduce injuries to the spine, leading to a decrease in pain [39]. In addition, core stability exercises appear to correct postural asymmetry, minimizing damage from uneven pressure on joints and intervertebral discs [5]. A study suggests that motor control disorders in the lumbopelvic region stemming from electromyographic activity disturbances in trunk muscles, such as the transversus abdominis and multifidus, could be a significant factor in triggering low back pain [7].

Improved motor control in this study may be ascribed to the alleviation of pain in patients, as pain can adversely affect lumbar motor control through alterations in muscle recruitment, impaired balance control, and proprioception [40]. Core stability exercises likely contribute to pain reduction and subsequent

improvements in motor control patterns in the lumbar region by enhancing stability, improving trunk muscle activity, and optimizing neuromuscular control[41]. However, further confirmation through electromyography or imaging studies is warranted. Despite these positive effects, motor control declined in the one-month follow-up, potentially due to the short duration of the exercise program, which may not have induced long-term adaptations. Notably, there is a lack of existing studies investigating the sustained impact of core exercises on motor control gains in chronic LBP. Previous studies suggest that low abdominal muscle strength is a contributing factor to LBP, and core stability exercises can address this issue by enhancing the volume and strength of trunk muscles[42, 43]. Furthermore, exercises may improve the activity and rhythm of core muscles in the lumbopelvic region; moreover, they can address dysfunction in deep trunk muscles, providing an effective strategy for alleviating chronic LBP[44, 45].

Stability exercises with Swiss balls offer considerable advantages over routine stability exercises due to their increased instability level. This dynamic surface requires greater muscle activation, potentially enhancing neuromuscular coordination and proprioception[13, 22]. Swiss ball exercises also allow for a more extensive range of motion, leading to more comprehensive muscle recruitment and engagement[19]. These exercises can result in more significant functional gains, improved core strength, and enhanced balance, making them valuable in rehabilitation programs for individuals recovering from low back pain or seeking injury prevention[32, 36]. In addition, Swiss ball exercises offer versatility and customization options to meet specific patient needs and abilities[17].

As evidenced by the results of our study, the practical implications of stability exercises with Swiss balls are wide-ranging. They can be used in clinical practice for rehabilitation, athletic training for injury prevention and performance enhancement, and preventive care settings. Individuals can also incorporate them into home exercise routines for long-term management of low back pain and overall fitness. Further research and education are necessary to optimize their use and ensure safe implementation across various settings.

The present study is subject to several limitations that could impact the robustness of its findings. Firstly, the small sample size may compromise the generalizability of the results. Furthermore, the relatively brief duration

of the exercise protocol might contribute to temporary and non-sustainable changes in motor control. Other limitations related to uncontrolled variables, such as sitting time, occupation, and sitting style, suggest that these results should be interpreted with great caution. Future research that accounts for these factors is necessary to validate and extend our findings. Another constraint is the absence of electromyography (EMG) or imaging methods, which, due to their cost, could hinder the establishment of a significant correlation between the findings and muscle activity or morphology.

Conclusion

A six-week core stabilization program on a Swiss ball demonstrated a significant positive impact on reducing pain intensity and enhancing motor control in individuals with nonspecific chronic LBP when compared to routine physical therapy. While the effects on pain intensity persisted during the one-month follow-up, improvements in motor control were not sustained. This outcome highlights the need for additional time-series studies or investigations involving subgroups undergoing different treatment modalities to explore these findings further and understand them.

Ethical Considerations

Compliance with ethical guidelines

This study obtained approval from the Ethics Committee of the Sport Sciences Research Institute (Ethics number: IR.SSRC.REC.1399.076), and all participants provided informed consent.

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Authors' contributions

All authors contributed equally to this article.

Conflicts of interest

The authors have no conflict of interest.

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