Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

Comparison of Postural and Functional Indicators in Adolescent Boys with and Without Non-specific Chronic Low Back Pain

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ARTICLE INFO

Article History:
Received: 21/11/2023
Revised: 19/04/2024
Accepted: 19/05/2024

Keywords:
Adolescent boys
Chronic non-specific low back pain
Core stability
Performance
Posture

Please cite this article as:
Yari Bishak M, Mohammad Ali Nasab Firouzjah E, Mohammadi Dangraloo M. Comparison of Postural and Functional Indicators in Adolescent Boys with and Without Non-specific Chronic Low Back Pain. JRSR. 2025;12(2):81-89. doi: 10.30476/jrsr.2024.100851.1448.

ABSTRACT

Background: Back pain is one of the most common disorders, caused by various factors and leading to diverse consequences. This study aimed to compare specific postural and functional indicators in adolescent boys with and without non-specific chronic low back pain.
Methods: The present study employed a causal-comparative design. A total of 30 adolescent male students with non-specific chronic low back pain and 30 healthy adolescent male students were purposefully selected. Individuals with non-specific chronic low back pain were identified using a visual pain scale and confirmed by a physical medicine specialist. Kyphosis and lordosis were assessed using a flexible ruler, proprioception was evaluated through the lumbar angle active reconstruction test at a 30-degree angle using a goniometer, core stability was measured using McGill functional tests, upper limb function was assessed with the Upper Limb Y Test, and static and dynamic balance were evaluated using the Stork Test and the Lower Limb Y Test, respectively. An independent t-test was used to compare the average variables between the two groups.
Results: The findings revealed significant differences in proprioception, core stability, and static and dynamic balance between the groups with and without non-specific chronic low back pain. However, the two groups observed no significant differences between other variables.
Conclusions: These results highlight the importance of proprioception, core stability, and static and dynamic balance in adolescent boys with non-specific chronic low back pain. Rehabilitation protocols for this population should prioritize developing and strengthening these components.

Introduction

Low back pain is one of the most prevalent musculoskeletal disorders globally [1], with its prevalence reported to be exceptionally high across the world population [2]. It is a multifaceted condition involving complex interactions among biological, psychological, and social factors [3]. Specific causes of low back pain have been identified in only 5 to 15 percent of cases, whereas more than 85 percent of patients suffer from non-specific back pain [3].

Low back pain is associated with various psychological, social, and biophysical factors, which may lead to dysfunction in daily performance, limited social participation, reduced job satisfaction, and adverse economic consequences [4]. Chronic non-specific low back pain is a prevalent and multifaceted condition characterized by an increased incidence, prolonged illness duration, elevated healthcare costs, and a higher risk of disability and comorbidities [5].

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Among the various types of chronic low back pain, non-specific back pain is the most common, accounting for approximately 90% of individuals with chronic back pain. This type of pain has no identifiable pathoanatomical cause, but without proper management, it can progress into chronic non-specific low back pain [6, 7].

The prevalence of back pain in adolescents is comparable to that in adults. Furthermore, when low back pain begins in adolescence, the risk of developing chronic non-specific low back pain in adulthood increases fourfold [8]. O'Sullivan et al. [9] reported a point prevalence of chronic non-specific low back pain of 20% in 17-year-old adolescents. This pain is associated with significant consequences, including reliance on medication, school absenteeism, reduced activity levels, and diminished quality of life.

Impairments in maintaining balance and postural control, difficulties in positional recreation, and altered movement perception are commonly observed in patients with chronic back pain. These impairments may stem from changes in the information relayed by mechanoreceptors, dysfunction of paraspinal muscle spindles, reduced strength, and coordination of muscle contractions, delayed activation of trunk muscles, or increased active muscle tension. Among these factors, alterations in proprioception are considered particularly significant contributors to balance disorders in individuals with back pain [10].

Dysfunction of the trunk muscles has been proposed as one of the key reasons for the persistence of back pain [11]. Core stability of the vertebral column is maintained by specific muscles that provide local intervertebral stability [12]. These include muscles with intervertebral connections that are particularly suited for intersegmental stability, such as the multifidus, transversus abdominis, and internal oblique muscles [13].

In healthy individuals, the transverse abdominal muscle activates before limb movement, ensuring spinal stability. However, in individuals with back pain, this muscle activates with a delay, causing limb movements without adequate spinal stability. This lack of stability predisposes the spinal column to inappropriate loads and back pain [14]. Additionally, reduced endurance of the multifidus muscles increases the likelihood of back pain [15]. In individuals with back pain, these muscles often exhibit atrophy and decreased electromyographic activity [16].

Some researchers suggest that extreme lumbar postures—hypo-lordosis or hyper-lordosis—represent altered muscle activity and stress patterns, which may contribute to chronic non-specific back pain. However, there is insufficient evidence to support this claim definitively [17]. It has also been observed that patients with chronic back pain, regardless of functional activity type, demonstrate increased activity in the back muscles [18].

A systematic review reported greater activation of back and abdominal muscles, coupled with reduced trunk mobility during movement, particularly in patients with chronic low back pain. However, the transverse abdominal muscle's activation delay persists in patients with chronic back pain during movement, and clinical trials suggest that changes in pain and disability do not consistently align with changes in deep muscle activity [18]. Furthermore, research indicates that performance, like muscle activity, differs between individuals with and without back pain [19, 20].

Given that low back pain is one of the most prevalent musculoskeletal disorders globally, with a relatively high prevalence rate, including among adolescent (student) boys, it is evident that addressing this issue is of critical importance. Mental and physical health is vital in achieving success, optimal performance, and desired outcomes. Therefore, by examining the findings of this study—which investigates differences in postural and functional characteristics between adolescent boys with and without chronic non-specific low back pain—strategies can be developed to address these differences (if any) in the research components. These strategies could focus on controlling and improving the condition while also implementing necessary measures to prevent its occurrence in the future.

Methods

The present study was descriptive and of a causal-comparative design. The statistical population included all male adolescent students aged 16–18 years [21, 22] in Tabriz city. The present study was descriptive and of a causal-comparative design. The statistical population included all male adolescent students aged 16–18 [21, 22] in Tabriz city. The study was approved by the ethics committee of Urmia University under the ethics code IR.URMIA.REC.1401.003. Additionally, written informed consent was obtained from all participants before their inclusion in the research.

The samples were selected using a convenience sampling method with voluntary consent. Sixty participants were divided into 30 healthy individuals and 30 individuals diagnosed with chronic non-specific low back pain. The sample size was determined using an a priori calculation for a T-test (two independent means) with the parameters α level=0.05, effect size=0.86, and actual power=95%. The minimum sample size required was n=30 per group, as calculated using G-Power software, which achieved the desired statistical power for analysis.

Participants with chronic non-specific low back pain were selected through purposive sampling. The inclusion criterion was a history of chronic non-specific low back pain lasting more than three months. The exclusion criteria included unwillingness to participate, any spinal inflammatory diseases, a history of back tumors or surgeries (e.g., severe sciatica), fractures or surgeries in the lumbar and thoracic spine, neurological disorders, respiratory diseases, rheumatism, spondylolysis, spondylolisthesis, and participation in therapeutic exercise programs for back pain within the past year.

The participants' height and weight were measured using a stadiometer to ensure accurate physical assessments. Other evaluations are explained below.

Assessment of Pain Intensity: The Visual Analogue Scale (VAS) was employed to evaluate pain intensity. This scale consists of a 10 cm horizontal bar, with "0" at one end, indicating no pain, and "10" at the other, representing severe pain.

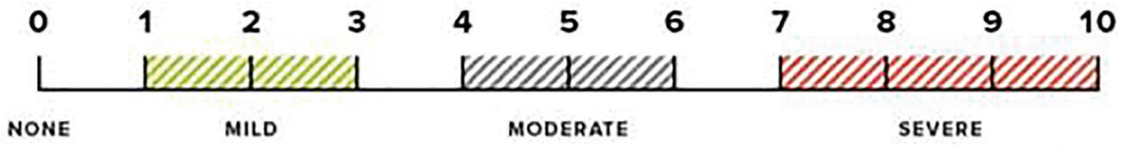

Figure 1: Visual Analogue scale (VAS)

Participants were asked to indicate the intensity of pain they experienced in the lumbar region by marking a point on the spectrum [23]. Pain intensity on the VAS was categorized into four levels: no pain (0 to 1 cm), mild pain (1 to 3 cm), moderate pain (4 to 6 cm), and severe pain (7 to 10 cm) [24]. The validity of this scale has been reported as 0.70, and its reliability as 0.97 [25] (Figure 1).

Assessment of Kyphosis and Lordosis: A flexible ruler was utilized to assess kyphosis and lordosis, with reported reliability ranging from 0.89 to 0.92 and validity of 0.91. Each subject was instructed to stand naturally in front of the evaluator with the trunk uncovered. All measurements were conducted in a relaxed standing position, ensuring the subjects distributed their weight equally on both legs and maintained a forward gaze throughout the evaluation.

To measure kyphosis, the evaluator marked the spinous processes of the second thoracic vertebra (T2) and twelfth thoracic vertebra (T12). Similarly, to measure lordosis, the evaluator marked the spinous processes of the first lumbar vertebra (L1) and the second sacral vertebra (S2).

The flexible ruler was placed along the spinous processes, shaped to follow the curvature of the spine. The positions of the marked vertebrae were transferred to the ruler. The ruler was then placed on paper without altering its curvature, and the spinal arc was traced. This measurement was repeated three times for accuracy.

To calculate the kyphosis angle [26], the formula $\Theta = 4\arctan 2H/L$, was used. For the lordosis angle, the formula $\theta = 4[ARCtan(2H/L)]$ was applied [27] (Figure 2).

Assessment of Lumbar Proprioception: Lumbar proprioception was assessed using the lumbar angle active reconstruction test at 30 degrees, performed with a manual goniometer with a reported validity of 0.87. The subject stood comfortably and steadily on a flat surface without shoes or socks for the test. To minimize errors caused by trunk and pelvic movements, the lower limbs—including the leg, knee, and thigh—were stabilized with elastic bandages.

The goniometer's center was positioned on the iliac crest, with its fixed arm aligned with the outer part of the thigh and its movable arm adjusted to 30 degrees of hip flexion. The subject was instructed to bend to a 30-degree angle with open eyes at a steady, slow pace, holding the position for five seconds before returning to the starting position. After three practice repetitions, the test phase required the subject to reconstruct the 30-degree flexion position with closed eyes.

This test was repeated thrice, and the error rate—calculated as the absolute value of the difference between the reconstructed and target angles—was recorded in degrees. The average error rate across the three repetitions was documented as the individual's proprioception error rate. Proprioception was considered healthy if the error rate was less than three degrees [28] (Figure 3).

Assessment of Core Stability: The McGill protocol assessed core stability. This protocol includes five tests designed to evaluate the endurance and strength of the core muscles: The *Trunk Flexor Endurance Test* assesses the functional endurance of the anterior core muscles, particularly the rectus abdominis. The subject began in a reclined position with their back supported by a 60-degree incline, both hips flexed at a 90-degree angle, and arms crossed over the chest. At the start of the test, the supporting board was moved 10 cm away from the subject's back, and they were instructed to maintain this position as long as possible. The test ended when the subject's back contacted the backrest. *The Trunk Extensor Endurance Test* evaluates the endurance of the posterior core muscles, particularly the erector spinae. The subject lay prone on a flat surface with their pelvis positioned at the edge of a table or bed. The examiner stabilized the

Figure 2: Assessment of lordosis and kyphosis curvature using a flexible ruler

Figure 3: Assessment of lumbar proprioception

Figure 4: McGill protocols

subject's lower limbs to ensure proper positioning. The subject was then instructed to hold their upper body horizontally, with arms crossed over the chest. The duration for which the subject maintained this position was recorded as their trunk extensor endurance. *The Side Plank Test* The side plank tests assess the lateral core muscles, particularly the quadratus lumborum. The subject was placed in a side-lying position, with the upper leg positioned in front of the lower leg and the hips aligned without flexion. The subject was then instructed to lift their thighs off the ground, using only the legs and one elbow for support while keeping the free arm aligned with the trunk. *The Front Plank Test* evaluates overall core stability. The subject assumed a prone position, supporting their body with their arms and toes while maintaining a neutral core position. The upper body, thighs, and legs were aligned straight. The test ended when the subject's body deviated from the neutral position, causing excessive spinal curvature [29] (Figure 4).

Assessment of Upper Limb Function: The Upper Limb Y Test was used to evaluate upper limb function. This test measures the ability to reach the upper limb in three directions and normalizes the results based on the length of the participant's hand. The device is a fixed plate with three wooden rods connected in three directions: internal, lower-external, and upper-external. The angles between the rods were designed as follows: 135 degrees between the internal and upper-external directions, 135 degrees between the internal and lower-external directions, and 90 degrees between the upper-external and lower-external directions.

Each wooden rod was marked in centimeters, and a movable marker was attached to each scaled rod, which the subject's free hand pushed to record the maximum reaching distance. First, the participant placed their dominant hand on the fixed plate for support in the Swedish swimming position. Using their non-dominant hand, they reached the maximum distance sequentially in three directions: internal, lower-external, and upper-external. After completing each reach, the participant returned to the initial position before beginning the next movement. Each direction was tested three times, and the average reaching distance for each direction was calculated. To normalize the results, the recorded distances were divided by the length of the upper limb (measured as the distance from the transverse process of C7 to the tip of the longest finger with the shoulder abducted at 90 degrees). The final score was determined by averaging the normalized distances across all three directions [30] (Figure 5) .

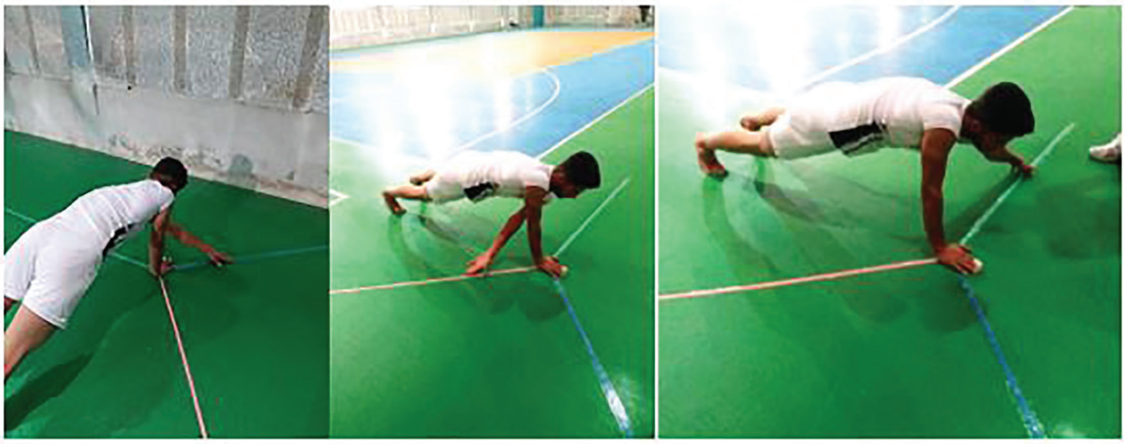

Figure 5: Assessment of upper limb function

Figure 6: Stork test

Figure 7: Y balance test

Assessment of Static Balance: The Stork Test was used to evaluate static balance. In this test, the participant stood barefoot on a flat surface with their hands on the iliac crests. The sole of the non-support leg was positioned against the inner side of the support leg while the participant maintained balance on the support leg. The participants practiced this position three times before the actual test. The timer started as soon as the heel of the supporting leg was lifted off the ground. During the test, the participant focused on a fixed point located four meters ahead, at eye level. The time the participant could sustain this position without errors was recorded as their score. The timer stopped when the following errors occurred: removing the hands from the iliac crests, swaying the support leg in any direction, losing contact between the non-support leg and the knee, and the heel of the support leg touching the ground. Each participant attempted the test three times, and the best time was recorded as their final score [31] (Figure 6).

Assessment of Dynamic Balance: The lower limb Y test, with a validity range of 0.80 to 0.90, was utilized to assess dynamic balance. After the examiner demonstrated the test, each participant was given two practice attempts to familiarize themselves with the procedure.

To begin with, the actual leg length (measured from the anterior superior iliac spine (ASIS) to the medial malleolus) was recorded to normalize the data and allow for accurate comparisons between participants. During the test, the subject stood at the center of the Y-shaped layout and balanced on their dominant leg while using the non-dominant leg to reach as far as possible in the specified directions. The three designated directions included anterior, posterior-lateral, and posterior-medial.

The toe of the non-dominant foot was used to touch the farthest reachable point in each direction, after which the participant returned to the starting position. The distance between the reach center and the point of contact was measured in centimeters. To minimize the impact of the learning curve, participants practiced each direction twice before starting the formal assessment.

During the test, participants were required to stand at the center of the Y layout, maintain balance on the dominant leg, and extend the non-dominant foot to touch the farthest point in the given direction without losing balance. The average reaching distance for all three trials in each direction was recorded. The results were normalized by dividing the reaching distances by the participant's leg length. The overall dynamic balance score was calculated by summing the averages of the three directional scores [32] (Figure 7).

Descriptive and inferential statistical methods were employed to analyze the collected data. The Shapiro-Wilk test was used to assess the normality of data distribution. The independent t-test was applied with a significance level set at $P<0.05$ to compare variables between the two groups. All statistical analyses were conducted using SPSS software, version 24.

Results

Table 1 presents the mean and standard deviation (SD) of the participants' characteristics, including age, height, weight, and body mass index (BMI). The independent t-test results (Table 2) confirm the homogeneity of these descriptive variables between the two groups.

Given that the Shapiro-Wilk test verified the normality of the data distribution, the independent t-test was utilized to compare variables between the groups. The results of these comparisons are summarized in Tables 2 and 3.

According to Table 2, the results of the independent t-test indicate that:

• No significant difference was found in the kyphosis angle, lordosis angle, and upper limb function between adolescent boys with and without chronic non-specific low back pain ($P\geq0.05$).

• A significant difference was observed in lumbar

Table 1: Demographic Characteristics of Participants in Affected and Healthy Groups

Indicator	Group	N	Standard deviation±Mean	P
Age (yr)	Affected	30	16.53±1.10	0.63
	Healthy	30	16.40±1.16	
Height (Cm)	Affected	30	166.97±11.12	0.87
	Healthy	30	164.33±10.79	
Weight (Kg)	Affected	30	65.13±9.31	0.58
	Healthy	30	64.30±10.61	
Body mass index (Kg/M^2)	Affected	30	23.85±4.03	0.90
	Healthy	30	23.93±3.95	

Table 2: Independent t-test Results Comparing Kyphosis Angle, Lordosis Angle, Lumbar Flexion Proprioception, and Upper Limb Function Between Two Groups

Variable	Group	Mean±Standard deviation	DF	T	P
Kyphosis angle (degree)	Affected	40.36±7.02	58	0.30	0.76
	Healthy	39.80±7.23			
Lordosis angle (degree)	Affected	31.49±6.85	58	0.97	0.33
	Healthy	29.86±6.05			
Proprioception (reconstruction error) Lumbar flexion (degree)	Affected	11.10±5.25	58	8.28	0.001**
	Healthy	2.62±1.95			
Upper limb function (cm)	Affected	41.28±7.36	58	-0.81	0.41
	Healthy	41.78±6.82			

**Significant difference between 2 groups

Table 3: Independent t-test Results Comparing Core Stability, Static Balance, and Dynamic Balance Between Two Groups

Variable	Group		Standard deviation±Mean	DF	T	P
Core Stability	Biering Sorensen (second)	Affected	22.60±4.17	58	-7.93	0.001**
		Healthy	35.83±8.12			
	Trunk flexion (second)	Affected	21.86±3.82	58	-8.22	0.001**
		Healthy	33.90±7.04			
	Left bridging (second)	Affected	28.46±4..20	58	-8.52	0.001**
		Healthy	41.73±7.41			
	Right bridging (second)	Affected	31.06±4.32	58	-8.67	0.001**
		Healthy	44.86±7.56			
	Abdominal bridging (second)	Affected	34.50±5.59	58	-5.865	0.001**
		Healthy	42.67±5.20			
Static balance (second)		Affected	11.80±4.61	58	-3.97	0.001**
Healthy		16.13±3.79				
Dynamic balance	Anterior direction (cm)	Affected	51.80±4.33	58	-8.56	0.001**
		Healthy	62.73±5.48			
	Internal posterior direction (cm)	Affected	57.90±3.89	58	-10.10	0.001**
		Healthy	69.17±4.69			
	External posterior direction (cm)	Affected	56.20±4.55	58	-8.82	0.001**
		Healthy	66.17±4.19			
	Overall dynamic balance (cm)	Affected	55.31±4.05	58	-9.37	0.001**
		Healthy	66.03±4.26			

**Significant difference between 2 groups

flexion proprioception between the two groups, with those experiencing back pain showing greater differences (P≤0.05).

Additionally, as shown in Table 3, the results reveal that:

• There is a significant difference in static balance, dynamic balance, and core stability between the two groups (P≤0.05).

Discussion

The present study compared postural and functional indicators in adolescent boys with and without chronic non-specific back pain. The results indicated a significant difference in proprioception, core stability, and static and dynamic balance between groups with and without chronic non-specific low back pain. However, no significant differences were observed in other variables between the two groups.

The present study showed no significant difference in kyphosis and lordosis angles between groups with and without chronic non-specific low back pain. The findings regarding kyphosis align with the studies of Asheghan et al., Mirbagheri et al., and Feng et al. [33-35] but not with those of Liu et al. and Tatsumi et al. [36, 37]. One possible explanation for this discrepancy is the assessment method. While radiography was used in some studies to detect spinal curvature, the present study employed a flexible ruler, which could account for the difference in results. Additionally, the limited statistical population in this study might have contributed to the disparity.

The findings regarding lordosis were consistent with the studies by Mirbagheri et al. and Sarikaya et al. [34, 38], but not with Youdas et al. [39]. A potential reason for these differing results is the age of the subjects. The present study focused on adolescents aged 16 to 18, whereas the study by Youdas et al. involved adult men and women with an average age of 54.9.

Despite the lack of significant differences in postural indicators between the two groups in this study, it is essential to acknowledge that increased cervical and lumbar lordosis and thoracic kyphosis are associated with improper posturing, which can ultimately lead to back pain [33].

The results of the present study suggested a significant difference in lumbar flexion proprioception between the two groups with and without chronic non-specific back pain. The group with back pain exhibited a higher average lumbar flexion reconstruction error than the healthy group. These findings regarding proprioception align with the research by O'Sullivan et al. [40] but contradict the results of Tong et al. [41]. The disparity could be attributed to differences in the assessment conditions used in the studies.

Cholewicki et al. reported that disorders in body proprioception can lead to delays in transmitting messages to the central nervous system, delays in muscle activation during sudden loads, and disturbances in factors such as reaction time, postural control, and balance. These issues can eventually result in spinal instability and lumbar-pelvic control disorders [42]. Furthermore, disorders in back proprioception can reduce the ability to achieve and maintain a neutral spinal position, leading to inconsistencies in muscle activation [41].

Based on this study's findings, the error in reconstructing the 30-degree flexion angle in the lumbar-pelvic region may be due to changes in the muscle activity pattern of the lumbar-pelvic area, decreased balance and related factors.

The present study's results demonstrated no significant difference in the upper limb performance between adolescent boys with and without chronic non-specific back pain. These findings contrast with those of studies by Beyranvand et al. and Zandi et al. [43, 44]. It has been suggested that certain musculoskeletal disorders, which alter the functional stability of the shoulder girdle, significantly increase the risk of injury to the upper limbs [45]. Chronic non-specific back pain is one such condition that can influence upper limb function [46].

Back pain can impact the activity of muscles surrounding the shoulder. As a result, it seems reasonable to associate this condition with changes in the motion performance of the shoulder joint [47]. Consequently, it was expected that a significant difference in upper limb function would be observed in adolescent male students suffering from chronic non-specific back pain. However, the present study did not confirm such a difference.

The disparity between this study's findings and prior research may stem from differences in study populations, including the type of subjects, age range, and whether participants were normal individuals or athletes. The absence of other abnormalities, such as round shoulder, kyphosis, or lordosis, could also contribute to the contrasting results.

The results of the present study showed a significant difference in core stability (test scores of Biering Sorensen, trunk flexion, abdominal bridging, right bridging, and left bridging) between the two groups with and without chronic non-specific back pain. The healthy group demonstrated higher average core stability than those with back pain.

Individuals with chronic non-specific low back pain are known to experience a reduction in overall body balance and a diminished sense of back position. Furthermore, they tend to exhibit increased muscle activity during core stability exercises. This heightened activity, often observed in patients with back pain, aligns with the present study's findings. Increased activity can lead to muscle fatigue, which subsequently reduces muscle endurance [34, 48, 49].

This study showed a significant difference in static and dynamic balance between the two groups, with the healthy group demonstrating better balance than the group with chronic non-specific back pain. These findings are consistent with those of Mazaheri et al. [50], Leitner et al. [51], and Ruhe et al. [52].

Balance relies on the proper interaction between the vestibular, visual, and proprioceptive systems [45]. The functionality of these systems can be compromised in individuals with chronic non-specific back pain [53]. Individuals with back pain tend to have reduced trunk muscle resistance compared to healthy individuals. Additionally, lumbosacral proprioception disorders are often linked to chronic back pain, and these disorders can further impair balance performance [45].

Conclusion

In conclusion, this study's results emphasize the importance of focusing on improving proprioception, core stability, and static and dynamic balance in adolescent boys with chronic non-specific back pain. These aspects should be carefully considered when designing exercise interventions for individuals experiencing chronic back pain.

In conclusion, this study's results emphasize the importance of focusing on improving proprioception, core stability, and static and dynamic balance in adolescent boys with chronic non-specific back pain. These aspects should be carefully considered when designing exercise interventions for individuals experiencing chronic back pain.

Acknowledgment

We would like to thank all the participants in this research.

Conflict of Interest: None declared.

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