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Comparison of Muscle Endurance and Balance in Patients with Shoulder Impingement and Healthy Controls

Omuz Sıkışma Sendromlu Hastalar ve Sağlıklı Kontroller Arasında Kas Dayanıklılığı ve Dengenin Karşılaştırılması

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Öz

Giriş ve Amaç: Kronik ağrının kas dayanıklılığından ödün vererek denge kontrolünü engellediği teorize edilmiştir. Bu teorik bağlantıya rağmen, özellikle omuz sıkışması olan hastalarda bu fenomene ilişkin klinik araştırmalar sınırlıdır. Bu çalışma, omuz sıkışması olan hastalarda kas dayanıklılığını, denge ölçümlerini ve omuz disfonksiyonu göstergelerini yaş ve cinsiyet açısından eşleştirilmiş sağlıklı kontrollerle karşılaştırarak araştırmayı amaçlamaktadır.
Gereç ve Yöntemler: Bu kesitsel çalışmada, omuz sıkışması olan hastalar (n=31) ve yaş ve cinsiyete göre eşleştirilmiş sağlıklı kontrol grubuyla (n=23), denge yetenekleri ve fiziksel performansları açısından karşılaştırıldı. Katılımcılar Kol, Omuz ve El Engellilikleri (DASH) anketi, Tek Bacak Duruş Denge Testi (TBDT), Y Denge Testi, Skapular Dayanıklılık Testi, Gövde kas fleksör ve ekstansör testi, kavrama gücü ve Dokuz Delikli Çivi Testi (NHPT) testlerini rastgele bir sırayla tamamladı.
Bulgular: Omuz ağrısı olan hastalarda omuz fonksiyonu (p<0.01), skapular ve gövde kas dayanıklılığı (p<0.01) ve sağ/sol denge baskın/nondominant denge yeteneği (p<0.01) ölçümlerinde sağlıklı bireylere göre anlamlı derecede daha düşük sonuçlar elde edildi.
Sonuç: Omuz sıkışması olan hastaların kas dayanıklılığı, denge ve el ölçümleri sağlıklı kişilere göre anlamlı olarak daha düşüktü. Sağlık ve fitness uzmanları, omuz sıkışması olan hastalara üst ekstremite egzersizlerini önerirken dengeyle ilişkili riskle ilgili ayarlamaları dikkate almalıdır.

Anahtar kelimeler: Denge yeteneği, ağrı, kas dayanıklılığı, omuz

Abstract

Aim; Chronic pain has been theorized to hinder balance control by compromising muscle endurance. Despite this theoretical connection, there is limited clinical research on this phenomenon, especially in patients diagnosed with shoulder impingement. This study aims to investigate muscle endurance, balance measures, and indicators of shoulder dysfunction in patients with impingement, comparing them with age- and sex-matched healthy controls.

Method; In this cross-sectional study, patients with shoulder impingement (n=31) and the healthy control group (n=23) matched for age and gender were compared with regard to their balance ability and physical performance. Functional questionnaires (Disabilities of the Arm, Shoulder, and Hand (DASH), as well as Single-Leg Stance Balance Test (SLBT), Y Balance test, Scapular Endurance Test, Trunk muscle flexor and extensor test, grip strength and Nine-Hole Peg Test (NHPT), were completed in a randomized order with consistent raters.

Results; Patients with shoulder pain showed significantly worse results in measurements of shoulder function ($p<0.01$), scapular and trunk muscle endurance ($p<0.01$), as well as balance dominant/nondominant balance ability right/left ($p<0.01$) compared to the control group.

Conclusion; Patients with shoulder impingement had significantly lower muscle endurance, balance and hand measurements compared with healthy controls. Health and fitness specialists should take into account the risk-related adjustments associated with balance when recommending upper-extremity exercises in patients with shoulder impingement.

Keywords: Balance ability, pain, muscle endurance, shoulder

1. Introduction

Among the disorders of the musculoskeletal system, shoulder pain is the third common symptom, following back and neck pain [1]. Moreover, the prevalence of shoulder pain caused by musculoskeletal disorders is widespread in the working-age population. This not only affects work-related functions but also impacts their overall quality of life [2].

Based on existing research, patients with shoulder impingement often have proprioceptive impairments in their shoulders, as well as coordination impairments in their trunk, arms, and lower extremities. Moreover, unrestricted shoulder function primarily depends on the trunk balance, which is closely related to the balance of the lower extremities and overall control of balance. Myers et al. [3] demonstrated that proprioceptive deficits result in abnormal proprioception throughout the muscle chain, affecting central control of the trunk. Consequently, these deficits can give rise to general functional problems, including various shoulder-related issues.

Akuthota et al. [4] posit that pain processing can contribute to a balance disability. A possible explanation is that pain processing affects the balance control circuit. Muscle inhibition and pain share some pathways in the central nervous system. The pathways induced by pain leading to muscle inhibition may, in turn, impair balance abilities. Muscular strength and endurance around the lumbar spine are essential for maintaining functional stability during limb movement. Trunk control, also known as core stability, has been identified as a pivotal element in biomechanical efficiency, enabling individuals to optimize muscle activation while minimizing pressures on peripheral joints. Additionally, a deficiency in trunk strength can result. Substantial research indicates that balance is a fundamental aspect of core stability, explained by an initial activation of trunk muscles and a subsequent delay in the activation of synergistic muscles, thereby predisposing individuals to injury [5].

Even though there is a lot of current interest in studying balance function, previous research on shoulder impingement has not adequately explored this aspect in different populations. Given the high prevalence of shoulder injuries across all age groups, there is a need to delve deeper into the differences between these injuries and the central control trunk, including the upper extremity, considering both strength and balance. Therefore, the purpose of this study was to analyse the disparities between individuals with healthy shoulders and those with shoulder dysfunction concerning muscle endurance, balance measures, and indicators of shoulder dysfunction.

2. Methods

2.1. Design and setting

This is a cross-sectional study conducted at the Orthopedics Department in Adana Orthopedic Hospital, Turkey, from July to November 2023. The study adhered to ethical principles required for human research in accordance with the Declaration of Helsinki (2013). The study participants were divided into two groups: the shoulder impingement group and the control group.

2.2. Sample size calculation

The effect size was determined to be 1.0 concerning the significant difference in the single-leg standing test based on a study that demonstrated clinically meaningful changes and estimated variability [6]. The minimum required sample size was determined using the sample size generation part of the PS-Power and SISA sample size program. With an effect size of 1.0, α value of 0.05, and power of 80%, the number of participants for each group was calculated to be 23, resulting in a total of 46 participants.

2.3. Participants

Patients diagnosed with impingement syndrome were referred to participate in our study. Participants who have experienced shoulder pain for a minimum duration of three months, and who report a Numeric Rating Scale (NRS) pain score of three or higher were accepted as chronic pain. The NRS rates the intensity of pain on a scale of 0 ("No pain") to 10 ("Worst possible pain")[7]. Inclusion criteria for the patient group were as follows: 1) shoulder pain diagnosed by a physician specialized in shoulders, and 2) unilateral shoulder pain in individuals aged 25–60, lasting for 3 months or longer, with a specified pain intensity. Patients with any of the following conditions were excluded from the study: a prior history of major surgery in the lower limbs, lower limb trauma within the last 6 months that affected function, spine or lower limb pain during the study session, neurological diseases, cardiovascular diseases, acute and chronic dizziness, inner ear diseases, and peripheral circulation disorders such as claudication. Control groups were recruited from the staff of Tarsus University and the community. Inclusion criteria for the control group were had similar gender and education level with the shoulder impingement group, no chronic pain and no diagnosis of any neurological disorders. A total of forty-two patients were screened for eligibility; six patients did not meet the inclusion criteria, and five patients refused to continue before data collection commenced. For the control group, thirty healthy participants were screened; seven of them did not meet the matching criteria. In total, there were 23 healthy participants and 31 participants with shoulder dysfunction.

2.4. Protocol

One of the researchers who is a physiotherapist, conducted a face-to-face interview to gather the participants' physical and social demographic information. Shoulder pain intensity was assessed using a 10-cm Visual Analogue Scale (VAS).

2.4.1. Scapular Muscle Endurance Tests

The Scapular Muscle Endurance Test was derived from a shoulder girdle muscle strengthening exercise [8] During this test, participants were required to stand. There was no contact between the participant's arms and the wall (Figure 1). The participant's hands were positioned around a digital dynamometer. The scapulae were kept in a neutral posture, and a flexible device was inserted between the subject's elbows to guarantee the maintenance of the test position. Afterwards, the participant was directed to externally rotate their shoulders in order to provide a 1-kg load and maintain this force, as seen on the dynamometer. The test was concluded when the individual reached a point where they were unable to maintain the specified resistance, release the adjustable spacer, or sustain a shoulder flexion angle of 90°. Previous studies have demonstrated that when the shoulder is externally rotated in this specific posture, it causes simultaneous activation of the trapezius and serratus anterior muscles. These muscles are known to play a crucial role in regulating the orientation and position of the scapula [9, 10].

Figure 1: Participant position for the Scapular Muscle Endurance Test.

The trunk extensor test is one of the most common procedures used to assess the stability of the back muscles. For the test measurement, participants were instructed to lie prone (using conventional gait belts) with their upper bodies supported by a chair extending off the end of the examining table. They were then told to maintain a constant contraction of their torso extensor muscles to the best of their ability. Time ceased when the subject was no longer able to maintain a straight trajectory or exceeded a maximum of 2 minutes [11].

The trunk flexor test is used to evaluate the assess the stability of the abdominal muscles. For the test measurement, participants were instructed to upper back position. They positioned their knees and hips at a 90° angle, then used leg straps over their toes to maintain this posture. At the start of the test, participants positioned their arms across their chest and maintained this posture while the helping wedge was pulled back by a distance of 10 cm. A period of time is halted when the angle of the trunk drops below 60 degrees [12].

2.4.2. Balance Tests

The Single-Leg Stance Balance Test (SLBT) was used in the past to evaluate the participant's capacity to sustain one leg balance with eyes closed [13]. Following a preliminary trial, three further trials were performed on each lower limb with closed eyes, arms crossed over the chest, the opposing leg slightly bent, and the foot positioned at the same level as the opposite ankle. The timer started at the elevation of the foot from the ground and concluded when the participant performed any of the following actions: opening their eyes, uncrossing their arms, shifting their weight, making contact between the elevated foot and the floor or stance leg, or moving the stance leg from its initial position. Furthermore, the test was terminated if the individual maintained the posture for a maximum duration of 45 seconds. Subsequently, the same process was replicated on the contralateral foot. The highest score for each foot was recorded.

The Y Balance Test (YBT) is an assessment designed to evaluate balance and neuromuscular control in the lower extremities, aiming to predict lower extremity injuries (Figure 2) [14]. Participants were first shown an instructional film on the YBT and completed six practice trials in order to reduce the possible influence of a learning effect. Following the instructional phase, participants positioned themselves on the central footplate, aligning the far end of their right foot with the starting line. During the single-leg stance on the right leg, individuals extended their left leg in three different directions relative to the stance foot: anteriorly, posteromedially, and posterolaterally, using the provided indication box to reach as far as possible.
Participants performed three consecutive trials for each reach direction, alternating limbs between each direction to mitigate fatigue. The testing order followed a specific sequence: right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral. The attempts were disregarded and repeated if the subject was unable to maintain a one-sided stance on the platform, failed to maintain contact between their reaching foot and the moving reach indicator on the target area, relied on the reach indicator for support, or failed to bring their reaching foot back to the initial position in a controlled manner. Each participant was allowed a maximum of six tries to successfully complete three attempts for each reach direction. The maximum and average distance attained after three successful attempts in each direction were recorded. To provide a consistent measurement for the subject's lower limb reach, it was divided by leg length, measured from the anterior superior iliac spine to the most distal section of the medial malleolus.

Figure 2: Participant position for the Y Balance Test

2.4.3. Upper Limb Strength, Dexterity and Disability Test

The measurement of grip strength was conducted using a Jamar Hand Dynamometer (Jamar Hand Evaluation Kit, Sammons Preston Ins., Bolingbrook, IL) [15] The participants were sat with their elbows positioned at a right angle and their wrists in a neutral posture. Three measurements were conducted on each side, and the average score was recorded.

The Nine Hole Peg Test (NHPT) is a commonly used dexterity challenge in numerous clinical populations [16, 17]. The NHPT requires participants to sequentially insert and then extract nine pegs into nine holes, one at a time, with utmost speed.

Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire mainly comprises a disability/symptom scale with 30 items. The research did not include the two optional scales of the DASH (sport/music and work). The disability/symptom scale consists of five answer possibilities for each item. A scale score, which ranges from 0 (indicating no impairment) to 100 (indicating the most severe handicap), may be determined if at least 27 out of the 30 items are completed.

2.5. Statistical Analysis

All statistical analyses were conducted using the IBM SPSS for Windows (Version 25.0. Armonk, NY: IBM Corp.). The normality of the variables was assessed through the Shapiro-Wilk test and examination of histograms. Descriptive statistics were employed to elucidate the comprehensive characteristics of the study population. Differences between the two groups were analyzed utilizing ANCOVA, with body mass index (BMI) serving as a covariate due to its significant disparity between the groups. The analysis aimed to explore potential differences in various variables between the two groups highlighting significant differences in BMI, pain intensity, and pain intensity at night between individuals with shoulder impingement and control group. Statistical significance was determined at p<0.05.

3. Results

A total of 54 participants took part as healthy controls. Table 1 presents the demographic and clinical characteristics of the study participants.

Table 1. Demographic and clinical characteristics of the participants (n=54)

Variable	People with shoulder impingement (n=31)	Control group (n=23)	p
Age (years)	45.0 (7.5)	42.8 (7.3)	0.281
Sex, n (%)			
Female	15 (48.4)	8 (34.8)	0.317
Male	16 (51.6)	15 (65.2)	
BMI (kg/m^2)	26.64 (3.49)	24.04 (2.34)	0.002*
Education level, n (%)			
Primary school	2 (6.5)	0 (0.0)	0.141
Secondary school	1 (3.2)	4 (17.4)	
High school	13 (41.9)	6 (26.1)	
University	15 (48.4)	13 (56.5)	
Dominant limb side, n (%)			
Right	27 (87.1)	23 (100.0)	0.073
Left	4 (12.9)	0 (0.0)	
Painful limb side, n (%)			
Right	19 (61.3)	-	-
Left	12 (38.7)	-	
Pain intensity	6.9 (1.6)	1.3 (1.1)	<0.001*
Pain intensity at night	5.7 (1.7)	1.0 (1.3)	<0.001*
Disease duration, months	8.6 (5.2)	-	-

*Significant difference at p<0.05.

BMI, body mass index.

Table 2 shows significant differences in endurance between individuals with shoulder impingement and control group. Scapular endurance was markedly lower in those with shoulder impingement, with a mean difference of 25.3 (95% CI: 17.3 to 33.3) and a percentage difference of -58.4% (F = 40.126, p < 0.001). Similarly, trunk flexor endurance was significantly reduced in individuals with shoulder impingement, with a mean difference of 29.5 (95% CI: 21.4 to 37.6) and a percentage difference of -57.1% (F = 53.558, p < 0.001). Moreover, trunk extensor endurance showed a significant decrease in individuals with shoulder impingement compared to healthy controls, with a mean difference of 30.2 (95% CI: 21.5 to 39.2) and a percentage difference of -56.9% (F = 47.202, p < 0.001).

Table 3 displays significant balance differences between individuals with shoulder impingement and control group. The Y-Test (right and left) and the Single Leg Stance Test (SLST) with eyes open and closed revealed notable deficits in balance for individuals with shoulder impingement (p < 0.001). For the Y-Test, participants with shoulder impingement showed reduced performance compared to control group, with highly significant differences in all Y-Test variations (p < 0.001). In the SLST with eyes open, individuals with shoulder impingement exhibited substantial balance deficits for both right and left sides (p<0.001). The SLST with eyes closed further highlighted significant balance impairments for both sides (p < 0.001).

Table 2. Endurance differences between people with shoulder impingement and control group.

Variable	People with shoulder impingement (n=31)	Control group (n=23)	Mean difference (95% CI)	Mean difference (%)	F	p
Scapular endurance (s)	17.7 (10.1)	43.3 (16.5)	25.3 (17.3, 33.3)	-58.4	40.126	<0.001*
Trunk flexor endurance (s)	21.0 (10.9)	51.7 (16.2)	29.5 (21.4, 37.6)	-57.1	53.558	<0.001*
Trunk extensor endurance (s)	22.6 (14.5)	53.1 (14.8)	30.2 (21.5, 39.2)	-56.9	47.202	<0.001*

*Significant difference at p<0.05.
CI, confidence interval.

Table 4 highlights substantial differences in upper limb strength, dexterity, and disability between individuals with shoulder impingement and control group, emphasizing the functional impairments associated with shoulder impingement. In individuals with shoulder impingement, grip strength (dominant and non-dominant) was significantly lower than in the control group, with mean differences of 27.1 (95% CI: 18.0 to 36.1) and 28.1 (95% CI: 17.7 to 38.6), representing percentage differences of -43.2% and -44.3%, respectively ($p < 0.001$ for both). The NHPT revealed significant differences in both dominant and non-dominant hands for individuals with shoulder impingement, with mean differences of -6.7 (95% CI: -9.3 to -4.2) and -7.0 (95% CI: -9.2 to -4.7), corresponding to percentage differences of 32.2% and 32.3%, respectively ($p < 0.001$ for both). The Quick-DASH scores indicated a substantial difference between the groups, with individuals with shoulder impingement exhibiting a mean difference of -50.8 (95% CI: -60.0 to -41.6) and a percentage difference of 87.1% ($p < 0.001$).

Table 3. Balance differences between people with shoulder impingement and control group.

Variable	People with shoulder impingement (n=31)	Control group (n=23)	Mean difference (95% CI)	Mean difference (%)	F	p
Y-Test-Right	106.4 (11.5)	127.9 (10.0)	20.9 (14.3, 27.5)	-16.3	40.240	<0.001
Y-Test-Left	106.1 (11.0)	126.4 (11.0)	19.2 (12.6, 25.9)	-15.2	33.801	<0.001
Y-Test-Composite	106.3 (11.2)	127.2 (10.2)	20.1 (13.6, 26.6)	-15.8	38.258	<0.001
SLST-Right-Eyes open (s)	27.0 (11.9)	48.8 (11.5)	21.6 (14.4, 28.7)	-44.3	36.871	<0.001
SLST-Left-Eyes open (s)	26.8 (11.2)	42.8 (13.0)	16.1 (8.8, 23.4)	-37.6	19.666	<0.001
SLST-Right-Eyes closed (s)	7.3 (3.7)	29.1 (12.6)	21.8 (16.5, 27.1)	-74.9	68.896	<0.001
SLST-Left-Eyes open (s)	7.7 (4.0)	27.8 (13.6)	18.9 (13.3, 24.5)	-68.0	45.491	<0.001

*Significant difference at p<0.05.
SLTS, Single Leg Stance Test.

Table 4. Upper limb strength, dexterity and disability differences people with shoulder impingement and control group.

Variable	People with shoulder impingement (n=31)	Control group (n=23)	Mean difference (95% CI)	Mean difference (%)	F	p
Grip strength-dom (kg)	37.4 (9.0)	62.8 (20.5)	27.1 (18.0, 36.1)	-43.2	36.271	<0.001*
Grip strength-non-dom (kg)	36.9 (10.9)	63.5 (23.3)	28.1 (17.7, 38.6)	-44.3	29.289	<0.001*
NHPT-dom (s)	20.8 (5.4)	14.2 (1.5)	-6.7 (-9.3, -4.2)	32.2	27.883	<0.001*
NHPT-non-dom (s)	21.7 (4.9)	14.1 (1.5)	-7.0 (-9.2, -4.7)	32.3	37.882	<0.001*
Quick-DASH (0-100)	58.3 (19.9)	10.2 (5.3)	-50.8 (-60.0, -41.6)	87.1	122.240	<0.001*

*Significant difference at p<0.05.

NHPT, Nine-Hole Peg Test; DASH, Disabilities of the Arm, Shoulder, and Hand; dom, dominant; non-dom, non-dominant.

4. Discussion

The purpose of this study was to identify differences in muscle endurance, balance measures, and indicators of shoulder dysfunction between individuals with healthy shoulders and those with shoulder impingement syndrome. The results showed a notable decrease in both balance and muscle endurance among participants with shoulder dysfunction compared to those with healthy shoulders.

Balance is a multifaceted process involving the maintenance of equilibrium through the integration of various neuromuscular activities, influenced by sensory and motor inputs [18]. Literature suggests a correlation between chronic pain conditions such as low back pain and knee issues and compromised balance, indicating a decline in postural stability with increasing pain severity [19-22]. Additionally, individuals experiencing shoulder pain exhibit deficiencies in proprioceptive input within their shoulder joints and lack coordination in their overall body and lower limbs [23]. Studies have shown compromised balance and postural stability in individuals with moderate to severe shoulder pain compared to the control group [18, 24]. For example, Pogetti et al. [25] observed reduced reaching distance among collegiate throwing athletes experiencing shoulder pain in the Y-Test.

Similarly, Youngwook et al. [26] found that overhead athletes with a history of shoulder injury demonstrated worse upper quarter Y-Balance Test balance versus those without the history. In our study, static and dynamic balance were assessed using the Y-test and SLBT test, respectively. Significant differences were noted in dynamic balance between the groups, which may be attributed to shared central nervous system pathways controlling both balance control and pain processing [27, 28].

Functional movement refers to the capacity to generate and sustain a harmonious relationship between mobility and stability along the kinetic chain while executing fundamental patterns with precision and effectiveness [29]. In our study, in addition to trunk muscle endurance, we evaluated serratus anterior and latissimus dorsi endurance, which contribute significantly to upper thoracic stability. Our study indicated that there was a significant decrease in scapular and trunk muscles in patients with chronic shoulder pain compared to healthy controls. This can be attributed to scapulothoracic joint stability. The stability of the scapulothoracic joint, primarily maintained by the connection of the trapezius and serratus anterior muscles, is crucial for ensuring core stability of the trunk and balance.

We found significant impairments in grip strength, dexterity, and overall upper limb functional ability in patients with shoulder impingement compared to healthy controls. These findings underscore the profound impact of shoulder impingement on upper limb function. The reduced grip strength and dexterity observed may be attributed to the pain and mechanical limitations associated with the condition, which can inhibit muscle performance and fine motor skills. These deficits can significantly affect daily activities, leading to increased disability as reflected in the Quick-DASH scores.

The results emphasize the need for tailored rehabilitation strategies that address these specific impairments. Effective treatment should incorporate exercises designed to improve both muscle strength and manual dexterity, considering the substantial functional limitations experienced by these patients. Additionally, understanding these limitations allows for the establishment of realistic recovery goals and helps manage patient expectations, ensuring that therapeutic interventions are aligned with the patient's current capabilities and functional needs. Ultimately, these insights guide more targeted and effective rehabilitation approaches, aiming to enhance functional outcomes and quality of life for individuals with shoulder impingement.

Several limitations of this study must be acknowledged, including a small sample size of participants with shoulder dysfunction, the absence of dynamic multi-planar testing protocols, and failure to examine prior minor cervical and lumbar injuries, known to affect the dynamic balance according to existing literature [30, 31]. Nonetheless, significant injuries such as fractures or operations were excluded to minimize outcome disparities. Despite these limitations, further clinical research is warranted.

The key finding of this study emphasizes that participants with shoulder impingement demonstrate significantly lower dynamic balance ability compared to healthy controls, alongside reduced muscle endurance and upper limb strength and dexterity. While these upper limb impairments are notable, the primary focus remains on the diminished balance ability observed in the shoulder impingement group. This highlights the need for physiotherapy approaches that address not only pain management but also specifically target balance improvement. Effective treatment should integrate balance training and exercises to enhance muscle endurance and upper limb function. By focusing on these areas, physiotherapy can more comprehensively support functional recovery and improve the overall quality of life for individuals with shoulder impingement.

5. Conflict of Interest Statement

The authors have no conflicts of interest to declare.

6. Ethical Approval

The protocol of the research project was approved by the Ethics Committee of Tarsus University Faculty of Health Sciences on 10.05.2022 (Protocol Number 2022-06-03) within which the work was undertaken and that it conforms to the provisions of the Declaration of Helsinki (as revised in Helsinki 2013). All the subjects gave informed consent and patient anonymity will be preserved.

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References

1. Chester R, et al. Predicting response to physiotherapy treatment for musculoskeletal shoulder pain: a systematic review. BMC Musculoskelet Disord. 2013;14:1-16.
2. Luque-Suarez A, et al. Spanish version of SPADI (shoulder pain and disability index) in musculoskeletal shoulder pain: a new 10-items version after confirmatory factor analysis. Health Qual Life Outcomes. 2016;14:1-8.
3. Myers JB, Wassinger CA, Lephart SM. Sensorimotor contribution to shoulder stability: effect of injury and rehabilitation. Man Ther. 2006;11(3):197-201.
4. Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil. 2004;85:86-92.
5. Hazar Z, Ulug N, Yuksel I. Is there a relation between shoulder dysfunction and core instability? Orthop J Sports Med. 2014;2(11 Suppl 3):2325967114S00173.
6. Radwan A, et al. Is there a relation between shoulder dysfunction and core instability? Int J Sports Phys Ther. 2014;9(1):8-13.
7. Jensen MP, et al. Comparative reliability and validity of chronic pain intensity measures. Pain. 1999;83(2):157-162.
8. Treede RD, et al. Cortical representation of pain: functional characterization of nociceptive areas near the lateral sulcus. Pain. 2000;87(2):113-119.
9. Boyling J, Jull G, eds. Grieve's Modern Manual Therapy: The Vertebral Column. 3rd ed. Churchill Livingstone; 2005.
10. Ekstrom RA, Donatelli RA, Soderberg GL. Surface electromyographic analysis of exercises for the trapezius and serratus anterior muscles. J Orthop Sports Phys Ther. 2003;33(5):247-258.
11. Demoulin C, et al. Spinal muscle evaluation using the Sorensen test: a critical appraisal of the literature. Joint Bone Spine. 2006;73(1):43-50.
12. Anderson D, et al. Core strength testing: developing normative data for three clinical tests. 2013.
13. Springer BA, et al. Normative values for the unipedal stance test with eyes open and closed. J Geriatr Phys Ther. 2007;30(1):8-15.
14. Plisky PJ, et al. The reliability of an instrumented device for measuring components of the star excursion balance test. North Am J Sports Phys Ther. 2009;4(2):92.
15. Mathiowetz V, et al. Reliability and validity of grip and pinch strength evaluations. J Hand Surg Am. 1984;9(2):222-226.
16. Svensson E, Häger-Ross C. Hand function in Charcot Marie Tooth: test retest reliability of some measurements. Clin Rehabil. 2006;20(10):896-908.
17. Earhart GM, et al. The 9-hole PEG test of upper extremity function: average values, test-retest reliability, and factors contributing to performance in people with Parkinson disease. J Neurol Phys Ther. 2011;35(4):157-163.
18. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age Ageing. 2006;35(Suppl 2).
19. Braga AB, et al. Comparison of static postural balance between healthy subjects and those with low back pain. Acta Ortop Bras. 2012;20(4):210-212.
20. Mingorance JA, et al. Differences in postural balance, pain sensitivity and depression between individuals with acute and chronic back pain. J Clin Med. 2022;11(10).
21. Ozcan Kahraman B, et al. Gender differences in postural control in people with nonspecific chronic low back pain. Gait Posture. 2018;64:147-151.
22. Liu C, et al. Factors associated with balance function in patients with knee osteoarthritis: An integrative review. Int J Nurs Sci. 2017;4(4):402-409.
23. Alfaya FF, et al. Shoulder proprioception and its correlation with pain intensity and functional disability in individuals with subacromial impingement syndrome: a cross-sectional study. Diagnostics (Basel). 2023;13(12).
24. Baierle T, et al. Balance ability and postural stability among patients with painful shoulder disorders and healthy controls. BMC Musculoskelet Disord. 2013;14:282.
25. Pogetti LS, et al. Core stability, shoulder peak torque and function in throwing athletes with and without shoulder pain. Phys Ther Sport. 2018;34:36-42.
26. Kim Y, et al. Comparison of shoulder range of motion, strength, and upper quarter dynamic balance between NCAA Division I overhead athletes with and without a history of shoulder injury. Phys Ther Sport. 2020;42:53-60.
27. Sullivan EV, et al. Postural sway reduction in aging men and women: relation to brain structure, cognitive status, and stabilizing factors. Neurobiol Aging. 2009;30(5):793-807.
28. Eker Y, Kaygısız BB. The effect of pain severity on balance, postural stability and fall risk in patients with shoulder pathologies. Arch Med Sci. 2021;17(2):390.
29. Mills JD, Taunton JE, Mills WA. The effect of a 10-week training regimen on lumbo-pelvic stability and athletic performance in female athletes: a randomized-controlled trial. Phys Ther Sport. 2005;6(2):60-66.

30. Chaudhari AM, et al. Lumbopelvic control and days missed because of injury in professional baseball pitchers. Am J Sports Med. 2014;42(11):2734-2740.
31. Yahia A, et al. Chronic neck pain and vertigo: is a true balance disorder present? Ann Phys Rehabil Med. 2009;52(7-8):556-567.