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DO CORE STABILIZATION EXERCISES HAVE AN IMPACT ON PAIN, POSTURE, AND DISABILITY IN SHOULDER IMPINGEMENT SYNDROME?

OMUZ İMPİNGEMENT SENDROMUNDA KOR STABİLİZASYON EGZERSİZLERİNİN AĞRI POSTÜR VE DİZABİLİTE ÜZERİNE ETKİSİ VAR MIDIR?

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ABSTRACT
The objective of this retrospective study was look into the effects of core stabilization exercises applied in conjunction conservative treatment on pain, muscle strength, disability, and posture in shoulder impingement syndrome (SIS). 92 patients diagnosed with SIS enrolled in the study. The study was completed with 50 patients who met the inclusion criteria and whose analyzes were fully completed. There were two groups in our study (Group 1: conservative treatment, Group 2: core stabilization in addition to conservative treatment, n=25 each groups, 3 days per week for 6 weeks). Pain, joint range of motion, muscle and core strength, core endurance, posture and disability were assessed pre and post treatment in both groups. Both groups showed that there were significant improvements in pain, shoulder and neck joint range of motion, core endurance, disability (all p<0.001), upper body region muscle strength (p<0.001 for Group 1, p=0.011-<0.001 for Group 2) and core strength (p=0.043-0.045 for Group 1, p<0.001 for Group 2) after treatment. Posture score compared with the pre-treatment there was no difference in the Group 1 (p=0,953), while there was a significant increase in the Group 2 (p<0.001). The Group 2 also showed a significant increase in the core strength and endurance score compared with the Group 1, (p<0.001). We observed both groups showed improvement in on pain level, range of motion, upper body region muscle strength, disability, core strength and endurance. It was found that the Group 2 provided superiority in core muscle strength and endurance compared to the Group 1 and posture improved significantly. These findings suggest that core stabilization exercises should be integrated into treatment plans, particularly for SIS patients with postural deficiencies.
Keywords: Core Stabilization Exercise, Disability, Muscle Strength, Pain, Posture, Shoulder Impingement Syndrome

ÖZET
Bu retrospektif çalışmanın amacı, omuzun subakromial impingement sendorumunda (SİS) klasik fizyoterapi programı ile birlikte uygulanan kor stabilizasyon egzersizlerinin ağrı, kas gücü, fonksiyonel kısıtlık ve postür üzerine etkilerini incelemektir. Çalışmaya SİS teşhisi konulan 92 hasta katılmıştır. Analizleri tam olarak tamamlanan 50 hasta ile çalışma tamamlanmıştır. Çalışmamızda iki grup vardı (Grup 1: klasik fizyoterapi programı, Grup 2: klasik fizyoterapi programına ek olarak kor stabilizasyon, n=25 (altı hafta)). Her iki grupta da tedavi öncesi ve sonrasında ağrı, eklem hareket açıklığı, kas ve kor gücü, kor dayanıklılığı, postür ve fonksiyonel durum değerlendirildi. Her iki grupta da tedavi sonrası ağrıda, omuz ve boyun eklem hareket açıklığında, kor dayanıklılığında, fonksiyonel durumda (tümü p<0.001), üst vücut bölgesi kas gücünde Grup 1 için p<0.001, Grup 2 için p=0.011-<0.001) ve kor gücünde (Grup 1 için p=0.043-0.045, Grup 2 için p<0.001) anlamlı iyileşmeler olduğu görüldü. Postür skorları tedavi öncesi ile karşılaştırıldığında Grup 1'de fark görülmezken (p=0.953), Grup 2'de anlamlı bir artış vardı (p<0.001). Grup 2 ayrıca Grup 1'e kıyasla kor gücü ve dayanıklılık skorunda da anlamlı bir artış gösterdi (p<0.001). Her iki grubun da ağrı düzeyini, hareket açıklığını, üst vücut bölgesi kas gücünü, fonksiyonel durumu, kor gücünü ve dayanıklılığını iyileştirdiğini gözlemledik. Klasik fizyoterapi programı grubuna ek olarak kor stabilizasyonun kor kas gücü ve dayanıklılığında üstünlük sağladığı ve postürün anlamlı şekilde iyileştiği tespit edilmiştir.
Anahtar Kelimeler: Ağrı, Dizabilite, Kor Stabilizasyon Egzersizleri, Postur, Subakromial İmpingement Sendromu

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INTRODUCTION

Shoulder pain is a prevalent musculoskeletal condition, affecting 16% of the population (Lucas et al., 2022), with a prevalence ranging from 0.67% to 55.2% in community settings and an annual incidence of 7.7 to 62 per 1000 persons (Hodgetts and Walker, 2021; Lucas et al., 2022). It is the third most common musculoskeletal complaint in primary care (Haas et al., 2023). Among shoulder pain causes, shoulder impingement syndrome (SIS) is the most common, accounting for 44-65% of all shoulder pain complaints (Page, 2011). Patients with SIS typically report pain during repetitive overhead activities or between 70° and 120° of arm elevation, often referred to as 'arch pain,' which radiates to the anterolateral region of the arm (Garving, 2017). SIS is caused by a combination of intrinsic factors, such as rotator cuff muscle weakness, tendon degeneration, and inflammation, and extrinsic factors, including acromial morphology, dysfunctional glenohumeral and scapulothoracic kinematics, capsular tightness or laxity, muscle imbalances, and poor posture. These factors collectively reduce shoulder function, cause muscle weakness and pain, limit joint movement, and significantly impair daily activities and quality of life (Mughrabive et al., 2016). Addressing both intrinsic and extrinsic factors is critical to SIS treatment. Non-surgical treatment of SIS incorporates various clinical methods, including anti-inflammatory medications, corticosteroid injections, electrotherapy agents, manual therapy, joint and soft tissue mobilization, proprioceptive neuromuscular facilitation (PNF) techniques, progressive resistive exercises, Kinesio® taping, and exercise therapy (Mughrabive et al., 2016; Haik et al., 2016). Core stabilization exercises, which target improved core strength, posture, and scapulothoracic stability, offer a promising approach to addressing the extrinsic factors contributing to SIS. These exercises may enhance overall shoulder biomechanics by providing a stable base for shoulder girdle movements, highlighting their potential benefit when integrated into treatment protocols for SIS patients, particularly those with postural deficiencies.

Core stabilization exercises, which have become a popular topic in physiotherapy and rehabilitation research in recent years, have been reported to be effective in preventing and treating many spines and lower extremity injuries. The aim of core stabilization training is to provide proper muscle balance around the lumbo-pelvic-hip complex, to provide a stable foundation for correct movement control while creating a rigid roller against body distortions (Mısırlıoglu et al, 2018). For proper load bearing on the pelvis, vertebrae, and kinetic chain, trunk stabilization is required. When this system is working properly, the loads on the body are distributed evenly. Excessive compressive, rotational, and bending load on kinetic ring joints is eliminated, resulting in optimal control and effective movement, adequate absorption of ground reaction force, and elimination of excessive compressive, rotational, and bending load on kinetic ring joints (Sciascia and Cromwell, 2012). Trunk stabilization exercises improve neuromuscular learning by providing neuromuscular facilitation as well as muscle strength (Akuthota and Nadler, 2004). In healthy individuals, trunk stabilization has been shown to improve balance and fine motor skills (Miyake et al., 2013). Trunk stabilization is referred to as the "powerhouse," and it is regarded as the foundation of all limb movement (Borghuis et al., 2008). During many activities, trunk muscle control is essential for the efficient transfer of energy from the trunk to the smaller extremities (Hodges, 2004).

The ability to control the workload in the upper extremity relies heavily on lumbar-pelvic and cervical stabilization. The work of the stabilizer trunk muscles prior to the arm muscles provides a controlled movement. Previous studies have demonstrated the activation of the core musculature during upper extremity movements, indicating a relationship between the shoulder and core muscles [Tananen et al., 2008; Moreside et al., 2007; Hodges and Richardson 1997a, Hodges and Richardson 1997b]. In a study conducted by Mısırlıoğlu et al. in young women, it was stated that 6-week core stabilization exercises positively affected the shoulder maximal voluntary isometric contraction strength and could be used to increase muscle strength in early shoulder rehabilitation. Although it has been advocated that core stabilization exercises be included in the rehabilitation program for shoulder injury [Brumitt and Dale, 2009; Radwan et al., 2014], there is still lack of evidences demonstrating the direct effect of core stabilization on shoulder pathologies and correlation between core stability and shoulder dysfunction (Mısırlıoglu et al., 2018; Radwan et al., 2014). Recent literature underscores the significance of scapular stabilization exercises in managing shoulder impingement syndrome (SIS). A systematic review by Ravichandran et al. (2020) demonstrated that such exercises effectively reduce pain and disability in SIS patients. Similarly, Zhong et al. (2024) confirmed the benefits of scapular stabilization exercises in alleviating subacromial pain syndrome. While these studies focus on scapular stabilization, the role of core stabilization exercises—which enhance trunk stability and may influence shoulder mechanics—has not been extensively explored in SIS treatment. As far as we know, no randomized or prospective data has been published on the effect of core stabilization exercises in SIS rehabilitation which is the most common shoulder pain. Therefore, we hypothesized that adding core stabilization exercises to conservative treatment may be improve pain, posture, and disability in patients with SIS compared with conservative treatment alone. As a result, the objective of the present retrospective study was to look into the effects of core stabilization exercises applied in conjunction conservative treatment on pain, muscle strength, disability, and posture in SIS.

MATERIALS AND METHODS

Patients and Study Design

The present study is a preliminary retrospective cohort study. The study was conducted retrospectively on 92 SIS patients applied to the Physiotherapy and Rehabilitation Department of a private hospital in Istanbul between the 1st of March and the 30th of August 2019. Yeditepe University Clinical Research Ethics Committee granted ethical approval for the study (Reference no: 37068608-6100-15-1757) in October 2019. Within the framework of the Helsinki Declaration, we obtained verbal and written consent from the patients who participated in the study to use their information verbally and in writing. Patients between the ages of 35 and 60 who were diagnosed by a Physical Therapy and Rehabilitation doctor with at least ten years of experience, whose SIS was confirmed by MRI, and who had shoulder complaints for at least six months were chosen for the study. Moreover, patients with positive signs (sensitivity 2%; specificity 60%), positive Hawkins-Kennedy test (sensitivity 79%; specificity 59%), significant loss of active and passive shoulder movements or painful range of motion (ROM), and patients whose treatment and evaluation methods were appropriate for the study design were also enrolled in the study. Patients who had upper extremity surgery, patients with a history of shoulder trauma and corticosteroid application to the shoulder region in the previous year, a history of shoulder dislocation, infection, tumor, adhesive capsulitis, reflex sympathetic dystrophy, congenital anomaly, rheumatic disease, and serious chronic systemic disease, professional athletes, and patients whose evaluations were missing in the previous year were excluded (Nakra et al., 2003). The study was completed with 50 patients who met the inclusion criteria and whose analyzes were fully completed. Figure 1 shows the flow diagram of patient selection. There were two groups in our study as follows:
Group 1 = The group in conservative treatment; n=25 (3 days per week for 6 weeks)
Group 2 = The group in which core stabilization was also performed in addition to conservative treatment; n=25 (3 days per week for 6 weeks)

Rehabilitation programs

Conservative treatment included transcutaneous electrical nerve stimulation [TENS, (Conventional TENS, 70-110 Hz, current time 40-100 microseconds, 30 min, Chattanooga® Intellect Legend XT 2 Channel Combination System, Hixson, Tennessee USA), infrared radiation for 15 min (Chattanooga®, Hixson, Tennessee USA), continuous ultrasound for 5 min (Chattanooga® Intellect Legend XT 2 Channel Combination System, Hixson, Tennessee USA) and home exercise program. For active assistive shoulder range of motion (ROM), home exercises included the Codman exercise, flexion exercise at the ladder, and the Wand exercise, as well as some strengthening and stretching exercises performed at the pain limit with 10 repetitions twice a day. Under the supervision of the same physiotherapist, active ROM, capsule stretching, rotator cuff muscles, rhomboid, levator scapula, and serratus anterior muscles strengthening exercises (with an elastic band) were performed three times per week. In addition these exercises, proprioceptive neuromuscular facilitation (PNF) exercises were performed to actively move through the PNF flexion abduction external-rotation diagonal pattern for three sets of ten repetitions with manual facilitation and contract-relax technique. The total time for the PNF intervention was approximately 10 minutes (Gorges et al, 2003, Al Dajah, 2014). Stretching exercises were also added to the necessary muscles, and brochures were given to the patients so they could do the appropriate exercises at home (Senbursa et al., 2007).

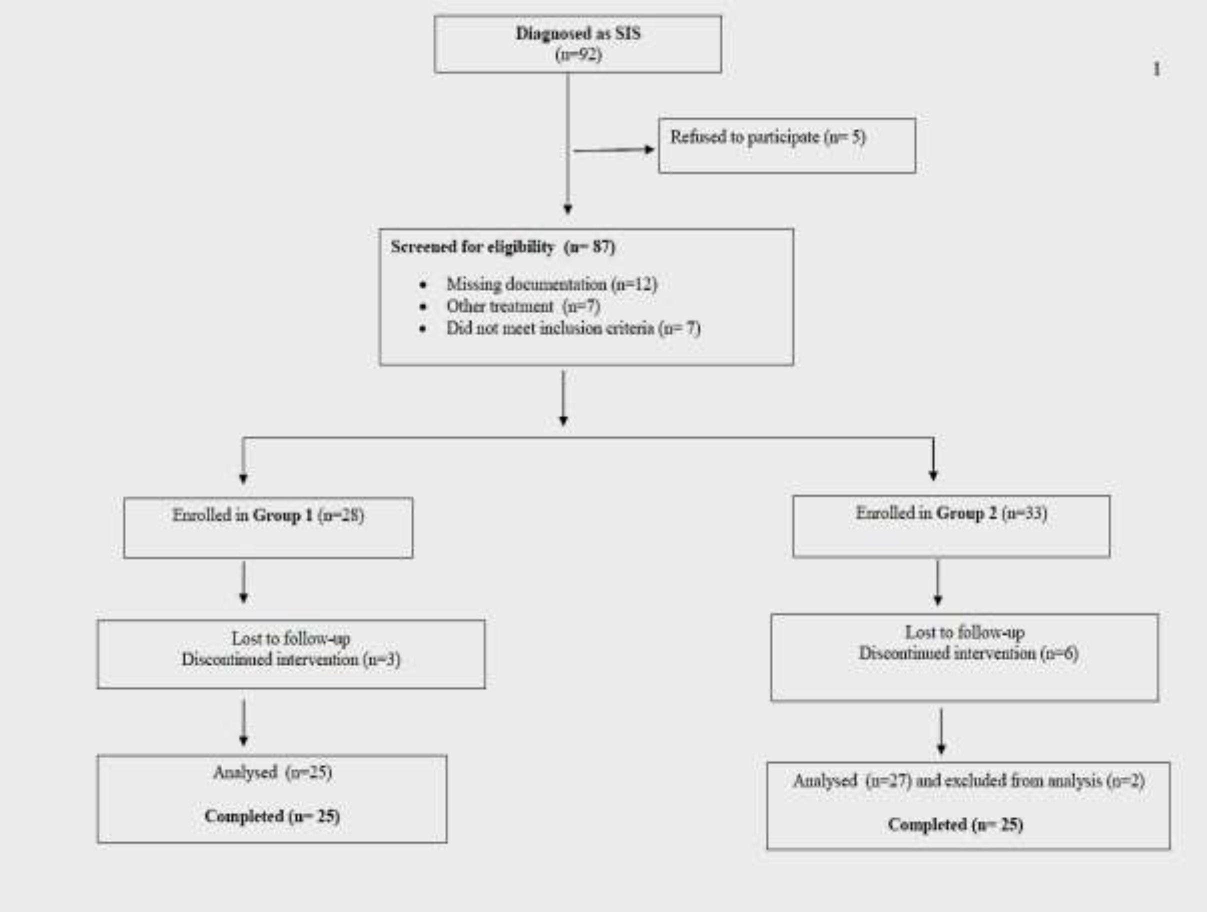

Figure 1. CONSORT Diagram for Patient Selection.

This diagram outlines the flow of participants through each stage of the study, including the number of patients assessed for eligibility, excluded with reasons, randomized into intervention groups, followed up, and analyzed. Group 1 represents patients receiving conservative treatment, and Group 2 represents patients receiving core stabilization exercises in addition to conservative treatment.

The interventions of the core exercise were applied when the patient lied on his/her back with his/her knees at flexion. The number of repeats for each exercise was five and these exercises were done 3 times a week for 6 weeks with the same physiotherapist. The further steps in the exercises were extended according to the activation duration of the core muscles, and this extention was elongated 5 s (Lust et al, 2009). The number of the core exercise for a patient was six, as explained below:

Dead insect exercise: The dead bug exercise involves lying face upon his/her mat with his/her arms in the air above his/her torso and his/her legs in the air with his/her knees bent at 90-degree angles. Then, he/she lower the opposite arm and leg toward the floor in a slow and controlled fashion. Return to center and then repeat on the other side.

Half shuttle exercise: In this intervention, the patient was asked to bring his/her both two arms at 45-degree flexion, and his/her eyes to point out toward a fixed point at the top. Then, he/she was required to stand up to his/her scapula, and stay at that position for 5 s.

Bridge exercise: Both legs of the patient were positioned at the flexion onto the bed. Then, the patient lied on his/her back with hands at the sides, knees bent, and feet flat on the floor under the knees. He/she stayed at this position for 5 s by activating the core muscles.

Dog peeing: With his/her leg away from you, he/she was asked to start with hip flexion, hip abduction, hip internal rotation, dorsiflexion, and eversion, followed by pulling the leg in and behind him/her to hip extension, hip adduction, hip external rotation, plantarflexion, and inversion. This position activated the core muscles and continued for 5 s.

The Wall sit exercise: The stabilization ball was placed on the back of the patient. Accordingly, he/she formed a right angle (90 degrees) at hips and knees, his/her back was flat against the wall, and the heels were on the ground by activating the core muscles for 5 s.

Stability ball workout: It was a workout targeting the core muscles, the patient was asked to start in a plank position with feet on a stability ball (toes pointed), engage core and pull knees forward until they're under hips, keeping hips level, return to plank position during 5 s.

Evaluations

At the beginning of the treatment, the physician recorded the sociodemographic status and disease characteristics of the patients in the patient files. Every one of the evaluations and treatments below was done by the same physiotherapist before and six weeks after the treatment, who also took notes.

Pain Evaluation

During rest and movement, the pain was evaluated using the Visual Analogue Scale (VAS). The VAS scale consists of a 10 cm horizontal line with a value of 0 at the beginning (left end) and a value of 10 at the end (right end). The patients were asked to rate the intensity of their pain, with no pain being the starting point and unbearable pain being the ending point. The scale point was measured with a ruler (in cm.) and recorded (Price et.al., 1983).

Evaluation of shoulder joint range of motion

A universal goniometer was used to measure the patients' active ROM of the shoulders and neck (lateral flexion and rotation) (UG; EZ Read Jamar Goniometer, Patterson Medical, Warrenville, IL). The Kendall – McCreary criteria were used in the measurements (Kendall et al., 1993). The measurements were repeated three times, with the average value recorded.

Evaluation of muscle strength

The same physiotherapist who performed manual muscle testing also tested the Serratus Anterior, Pectoralis Major, Upper Trapezius, and anterior Deltoid muscles (Kendall, 2005). These muscles were considered suitable for muscle testing because muscle tests of these muscles did not cause pain in the patients at the start of treatment.

Evaluation of Core muscle strength

The strength of Core Muscles was evaluated using Sharmann Protocol (Chan et al., 2020). The measurements were repeated 3 times, and the average value was used. With the Sharmann test, a transducer is placed under the patient's lumbar spine while he/she lies supine in a hook-lying position. Then, the pressure biofeedback unit (Stabilizer Pressure Biofeedback Unit, Chattanooga Group Inc., Hixson, TN 37343, USA) is inflated to 40 mm Hg, while the patient activates the stabilizing musculature via abdominal hollowing technique. This maneuver either isolates the Transversus abdominis muscle or ensures core stability. The test consists of 5 stages. Participants were instructed to perform abdominal bracing at each stage of the test, as well as various lower extremity movements while maintaining this position .The level of difficulty has been raised from stage 1 to stage 5. When the value in the stabilizer changed by more than 10 mmHg during each stage, it was determined that the person was unable to complete the level and so the test was terminated.

Endurance of Core Muscles

The endurance of core muscles was evaluated by using Sorensen, front plank, and right and left bridge tests. Each test was repeated three times, and the average of the measurements was used. The Biering-Sørensen test measures how many seconds the participant is able to keep the unsupported upper part of the body in a horizontal position. In this test, the load is equal to the weight of the upper part of the body, with torque determined by the lever arm from the pubic symphysis to the upper body center of gravity. The participant was positioned prone over an examination table. The lower extremities were stabilized by 2 belts at the level of the hips and just below the knees. The iliac crests were positioned at the edge of the table with the trunk extended beyond the table and initially hanging flexed at 90°. The trunk then was raised to the horizontal position with hands crossed over the chest. The test was continued until the participant could no longer control the horizontal posture, or until he or she reached the limit of fatigue pain.

Right and left side bridge endurance abilities were recorded. Every participant was instructed to lie down on either side and bear upper trunk weight on arm with shoulder abducted to 90º and elbow flexed to 90º. Every participant was instructed to put the non-weight arm across the chest with keeping the hand on the opposite shoulder. The lowermost leg was maintained in semi flexed position while the uppermost leg was put just anterior to the other leg. Each holding time was recorded using a stopwatch (El-Gohary, 2018).

For the prone plank test, participants maintained a prone position in which the body weight was supported by the toes and forearms. The side plank test was performed with the participant lying on their side, supported by the foot and elbow. The side plank test was performed on both sides. Participants were instructed to maintain a neutral position of the spine and pelvis, and to breathe normally during testing. Each test was terminated when the participant was unable to maintain their posture, or their pelvis moved up or down five or more cm. Each holding time was recorded using a stopwatch. The holding time of the prone plank test, right and left side plank tests, and the combined score of all plank tests were used for analyses (Tse et al., 2005).

Posture Evaluation

Study participants were assessed employing the New York Posture Rating Method to determine their postures (NYPA). The NYPA applies a quantitative approach to assess the proper and improper alignment of various body segments for an individual in the anatomical position. It includes a set of three 8igüre drawings for each of the 13 body alignment segments contributing to overall posture alignment. The 13 body alignment segments include posterior views of the head, shoulders, spine, hip, feet, and arches, and lateral (left side) views of the neck, chest, shoulders, upper back, trunk, abdomen, and lower back (Mcroberts et al., 2013).

Evaluation of Disability

The shoulder pain and disability index (SPADI) is a questionnaire designed to assess the pain and disability associated with shoulder pain. It is divided into two sections, pain, and disability, and consists of 13 questions in total. The subgroup of the questionnaire that evaluates pain contains 5 questions, and the patient is asked to express the severity of the pain during various activities in the previous week by scoring between zero (no pain) and ten (extreme pain). 8 questions in the subgroup evaluate the disability, and the patient is asked to rate how much difficulty he has had during the various activities in the last week, ranging from zero (no difficulty) to ten (extreme difficulty). A total score of zero indicates maximum well-being, while a total score of 130 indicates maximum illness (Bumin et al., 2008).

Statistical analysis

The sample size calculation was performed using the G*Power V.3.1.7 software (University of Kiel, Kiel, Germany). Based on the primary objective of the study, which is to assess the effects of core stabilization exercises on pain, muscle strength, disability, and posture in patients with shoulder impingement syndrome, the calculation focused on the effect size for changes in pain levels (primary outcome). A total sample size of 46 patients was determined to be sufficient to detect a moderate effect size (Cohen's f = 0.25) with 80% power at a significance level of 0.05 within a 95% confidence interval. This sample size was informed by previous studies with similar methodologies and outcomes (Cıtaker et al., 2005; Tse et al., 2005).

Statistical analyses were made using SPSS-21.0 software (SPSS Inc., Chicago, IL). The Shapiro-Wilk test was used to determine the data's conformity to the normal distribution. Baseline demographic data were compared between treatment groups using independent sample t-test nd chi-square test for continuous and categorical variables. Pre-treatment and post-treatment values within the groups were compared with paired sample t-test. The analysis of group and time-dependent changes for each evaluation criterion was performed using repeated measures ANOVA in the comparison of the groups with each other. For all tests, the statistical level of significance was determined as $p<0.05$. For each treatment, effect size (ES) was calculated using Cohen's formula. For intra-group comparisons, ES values of 0.2, 0.5, and 0.8 were considered as small, moderate and large, respectively [Cohen, 1977].

RESULTS

In terms of demographic and disease characteristics, there was no statistical difference between groups (p = 0.083-0.987, Table 1). While both rest and movement pain decreased statistically after treatment ($p < 0.001$ for all, Table 2), there was no difference between the groups ($p = 0.756$ for rest pain, $p=0.061$ for movement pain, Table 2). In both groups, active range of motion measurements of the shoulder and neck joints increased significantly after treatment ($p<0.001$ for all, Table 2). Joint range of motion measurements did not differ between groups (p = 0.224-0.365, Table 2).

While there was an increase in muscle test measurements of the serratus anterior, pectoralis major, upper trapezius, and anterior part of the deltoid after treatment in the group evaluation (p= 0.043-0.001, Table 3), there was no significant difference between the groups (p= 0.203-0.503, Table 3). While both groups experienced a significant increase in core muscle strength and endurance following treatment (p= 0.043-0.001, Table 3), the Group 2 experienced a significant increase (p<0.001 for all, Table 3).

While there was no difference in the in-group assessment of the Group 1 in the New York Posture Assessment Method scores (p= 0.953, Table 3), there was a significant increase in the posture scores of the Group 2 (p<0.001, Table 3). In the comparison of posture between groups, the Group 2 group had a significant advantage (p<0.001, Table 3). While SPDI measurements decreased statistically significantly in both groups (p<0.001, Table 3), there was no significant difference between groups (p = 0.238, Table 3).

While there was no superiority of the groups over each other in the effect value results, it was determined that the treatment methods had a very high effect value in many evaluation parameters (except core muscle strength, endurance, and posture values in the Group 2) (effect value >0.8, Tables 2 and 3).

Table 1. Demographic characteristics of the individuals

Parameters		Group 1	Group 2	p
Age		48.16 ± 9.41	48.00 ± 7.90	0.948[a]
Sex				
	Male	7 (28.00 %)	11 (48.00 %)	0.083[b]
	Female	18 (72.00 %)	13 (52.00 %)	
Dominant side				
	Right	22 (88.00 %)	24 (96.00 %)	0.297[b]
	Left	3 (12.00 %)	1 (4.00 %)	
Affected Shoulder				
	Right	15 (60.00 %)	17 (68.00 %)	0.700[b]
	Left	10 (40.00 %)	8 (22.00 %)	
Symptom Duration (month)		8.04 ± 2.35	7.96 ± 2.05	0.880[a]
Shoulder Impingement Syndrome phases				
	Stage 1	1 (4.00 %)	1 (4.00 %)	0.894[b]
	Stage 2	21 (84.00 %)	22 (88.00 %)	
	Stage 3	3 (12.00 %)	2 (8.00 %)	

Group 1, conservative treatment; Group 2, the group in which core stabilization was also performed in addition to conservative treatment; mean standard error; n number (percentage of frequency); a, independent samples t test, b, chi-square tes

Table 2. Intragroup and intergroup comparison of pain and range of motion assessments

Parameters	Groups	Before treatment	After treatment	Within-group score change	Effect size	Intragroup evaluation (p)[a]	Intergroup evaluation (p)[b]
Pain (cm)							
Rest pain	*Group 1*	6.32 ± 1.37	2.04 ± 1.45	4.28 ± 1.92	3.24	**<0.001**	0.756
	Group 2	6.44 ± 1.91	2.00 ± 1.32	4.44 ± 1.50	2.32	**<0.001**	
Pain with Movement	*Group 1*	7.88 ± 0.92	2.12 ± 1.39	5.76 ± 1.53	6.26	**<0.001**	0.061
	Group 2	6.92 ± 1.44	2.00 ± 1.32	4.92 ± 0.99	3.41	**<0.001**	
Shoulder Joint Active Range of Motion (degrees)							
Flexion	*Group 1*	129.44 ± 27.34	167.44 ± 10.23	38.00 ± 20.60	1.38	**<0.001**	0.224
	Group 2	136.00 ± 26.35	167.44 ± 9.54	31.44 ± 18.60	1.19	**<0.001**	
Abduction	*Group 1*	110.42 ± 22.34	150.35 ± 13.23	39.93 ± 9.22	1.78	**<0.001**	0.365
	Group 2	115.22 ± 23.22	152.32 ± 7.62	37.10 ± 15.95	1.59	**<0.001**	
External rotation	*Group 1*	43.52 ± 16.01	64.96 ± 13.00	21.44 ± 7.08	1.34	**<0.001**	0.365
	Group 2	47.92 ± 16.41	66.72 ± 18.73	18.80 ± 13,67	1.14	**<0.001**	
Internal rotation	*Group 1*	46.18 ± 14.21	67.87 ± 15.60	21.69 ± 1.59	1.53	**<0.001**	0.225
	Group 2	49.42 ± 11.21	69.85 ± 14.48	20.43 ± 3.46	1.82	**<0.001**	
Neck joint Active Range of Motion (degrees)							
Right Lateral Flexion	*Group 1*	33.84±5.35	39.44±1.22	5.60±4.54	1.04	**<0.001**	0.475
	Group 2	34.08±5.46	38.72±2.99	4.64±5.25	0.84	**<0.001**	
Left Lateral Flexion	*Group 1*	32.64±6.42	38.80±2.51	6.16±4,79	0.95	**<0.001**	0.998
	Group 2	32.64±6.80	38.80±2.16	6.16±5.19	0.91	**<0.001**	
Right rotation	*Group 1*	49.48±3.35	54.56±1.00	5.08±2,78	1.51	**<0.001**	0.320
	Group 2	48.56±4.55	54.44±1.26	5.88±3.63	1.29	**<0.001**	
Left rotation	*Group 1*	50.20±3.40	54.56±1.00	4.56±3,04	1.34	**<0.001**	0.584
	Group 2	49.56±4.09	54.56±1.00	5.00±3.46	1.22	**<0.001**	

Group 1, conservative treatment; Group 2, the group in which core stabilization was also performed in addition to conservative treatment; a, the paired samples t-test; b, repeated measurements ANOVA; mean ± standard error, Effect size = <0.20 a small effect, 0.20- 0.50 a moderate effect, 0.50-0.80 a large effect, > 0.80 a very large effect, Bold values indicate statistical significance within the group or between groups.

Table 3. Intra-group and intergroup comparison of muscle strength, posture and disability assessments, as well as effect size

Parameters	Groups	Before treatment	After treatment	Within-group score change	Effect size	Intragroup evaluation (p)[a]	Intergroup evaluation (p)[b]
Muscle strength							
Serratus Anterior	*Group 1*	4.16 ± 0.55	4.80 ± 0.40	0.64 ± 0.56	1.16	**<0.001**	
	Group 2	4.24 ± 0.72	4.68 ± 0.47	0.44 ± 0.58	0.61	**0.001**	0.203
Pectoralis Major	*Group 1*	4,16 ± 0.74	4.76 ± 0.43	0.60 ± 0.70	0.81	**<0.001**	
	Group 2	4.16 ± 0.62	4.64 ± 0.48	0.48 ± 0.58	0.77	**<0.001**	0.503
Upper Trapezoid	*Group 1*	4.84 ± 0.37	5.00 ± 0.00	0.16 ± 0.37	0.43	**0.043**	0.491
	Group 2	4.60 ± 0.50	4.84 ± 0.37	0.24 ± 0.43	0.48	**0.011**	
Anterior Deltoid	*Group 1*	3.96 ± 0.53	4.64 ± 0.48	0.68 ± 0.62	1.28	**<0.001**	0.250
	Group 2	3.92 ± 0.70	4.60 ± 0.50	0.68 ± 0.88	0.97	**<0.001**	
Strength of core muscles							
Core Strength of Waist Area	*Group 1*	1.44 ± 0.65	1.60 ± 0.64	0.16 ± 0.37	0.24	**0.043**	**<0.001**
	Group 2	1.68 ± 0.69	3.08 ± 0.75	1.40 ± 0.50	2.02	**<0.001**	
Core Strength of Neck	*Group 1*	2.28 ± 0.97	2.44 ± 0.96	0.16 ± 0.37	0.16	**0.045**	**<0.001**
	Group 2	2.28 ± 1.17	3.64 ± 0.90	1.36 ± 0.70	1.16	**<0.001**	
Core endurance							
Sorensen Test	*Group 1*	10.25 ± 3.32	15.91 ± 2.88	4.75 ± 1.35	1.43	**<0.001**	**<0.001**
	Group 2	10.54 ± 3.30	14.81 ± 2.75	8.50 ± 2.15	2.57	**<0.001**	
Prone Plank Test	*Group 1*	13.14 ± 3.68	17.94 ± 3.47	4.80 ± 1.15	1.30	**<0.001**	**<0.001**
	Group 2	13.09 ± 3.60	24.28 ± 3.57	11.18 ± 2.18	3.10	**<0.001**	
Right Bridge	*Group 1*	11.79 ± 4.08	16.56 ± 3.92	4.77 ± 0.79	1.17	**<0.001**	**<0.001**
	Group 2	11.64 ± 3.79	21.74 ± 3.56	10.10 ± 1.79	2.66	**<0.001**	
Left Bridge	*Group 1*	11.45 ± 3.96	17.26 ± 3.91	5.80 ± 0.99	1.46	**<0.001**	**<0.001**
	Group 2	11.51 ± 3.41	20.64 ± 3.15	9.13 ± 1.78	2.68	**<0.001**	
The New York Posture Rating Method	*Group 1*	41.36 ± 7.21	43.36 ± 6.86	2.00 ± 1.52	0.27	0.953	**<0.001**
	Group 2	41.48 ± 6.32	51.40 ± 5.15	9.92 ± 2.03	1.57	**<0.001**	
Shoulder Pain and Disability Index	*Group 1*	65.49 ± 7.23	54.62 ± 6.85	10.86 ± 2.47	1.50	**<0.001**	0.238
	Group 2	64.36 ± 8.61	51.96 ± 8.12	12.39 ± 2.23	1.44	**<0.001**	

Group 1, conservative treatment; Group 2, the group in which core stabilization was also performed in addition to conservative treatment; a, the paired samples t-test; b, repeated measurements ANOVA; mean ± standard error, Effect size =<0.20 a small effect, 0.20- 0.50 a moderate effect, 0.50-0.80 a large effect, > 0.80 a very large effect, Bold values indicate statistical significance within the group or between groups.

DISCUSSION

SIS is one of the most common shoulder disorders with significant socioeconomic impact. It is exacerbated by raising the arms or performing overhead activities, interfering with a person's daily life and work activities (Senbursa et al., 2007). Effective treatment is crucial to mitigate these impacts (Mughrabi et al., 2016). This study aimed to investigate the effects of core stabilization exercises combined with conservative treatment on pain, muscle strength, disability, and posture in SIS patients.

Both groups in our study showed significant improvements in pain, neck and shoulder active joint range of motion, muscle strength, and disability after six weeks of treatment. These findings align with previous literature demonstrating the efficacy of conservative treatments such as physiotherapy modalities, passive-active ROM exercises, and PNF techniques in managing SIS (Citaker et al., 2005; Oledzka et al., 2017). However, the addition of core stabilization exercises provided notable superiority in improving core muscle strength, endurance, and posture, which has not been extensively explored in previous studies.

SIS results from intrinsic factors (e.g., rotator cuff vascularity, tendon degeneration, anatomical variations) and extrinsic factors (e.g., muscle imbalances, postural changes, repetitive overhead activities) (Donatelli, 2004). While conservative treatment often addresses these factors, integrating core stabilization exercises offers an additional focus on trunk stability, which supports the principle of proximal stability for distal mobility (Borghuis et al., 2008). Our findings build on studies by Shinkle et al. (2012) and Tarnanen et al. (2013), which highlight the relationship between trunk stabilization and upper extremity function.

Studies by Yorukoglu et al. (2017) and Hazar et al. (2014) indicate that poor core stability correlates with shoulder dysfunction, advocating for the inclusion of core stabilization in SIS rehabilitation. Similarly, we observed that Group 2, which received core stabilization exercises, demonstrated significant improvements in posture compared to Group 1. This supports the hypothesis that core exercises enhance trunk awareness and control, leading to improved balance and postural alignment (van Dieën et al., 2010).

Our findings suggest that core stabilization exercises may be an integral part of rehabilitation protocols for patients with SIS, particularly those with postural deficiencies. The significant improvements in posture and core strength observed in this study indicate that targeting trunk stability can address underlying biomechanical imbalances that exacerbate SIS. Future rehabilitation protocols could incorporate individualized core stabilization programs tailored to patients' postural and functional needs, potentially reducing the recurrence of symptoms and enhancing long-term outcomes. However, both groups showed similar improvements in pain, range of motion, and upper body strength. These findings suggest that while core stabilization exercises may not directly affect pain or range of motion beyond standard conservative treatment, they play a critical role in addressing postural deficiencies, a known contributor to SIS pathogenesis.

The primary limitation of this study is its retrospective design, which may introduce biases in data collection and limit causal inferences. Additionally, the relatively short follow-up period restricts the ability to assess the long-term effects of core stabilization exercises. Another limitation is the inclusion of PNF exercises in both groups, which may have influenced the results and masked the full extent of the benefits provided by core stabilization exercises. Furthermore, the study's sample size and specific inclusion criteria may limit the generalizability of the findings. To address these limitations, future research should focus on prospective, randomized controlled trials with larger and more diverse patient populations. Extended follow-up periods are also necessary to evaluate the sustainability of the observed effects. Moreover, isolating core stabilization exercises from other interventions, such as PNF techniques, could provide clearer insights into their specific impact on SIS rehabilitation. These future studies will be critical for validating and expanding upon our findings and enhancing the applicability of core stabilization exercises in clinical practice.

CONCLUSION

This study demonstrated that conservative treatment, with or without core stabilization exercises, has beneficial effects on pain, active range of motion of the neck and shoulder, muscle strength, and disability in SIS patients. However, the addition of core stabilization exercises resulted in superior improvements in core muscle strength, endurance, and posture, highlighting their value, particularly in SIS patients with postural deficiencies. These findings underscore the importance of incorporating core stabilization exercises into treatment plans for SIS, especially for addressing postural insufficiencies. Future research should focus on long-term outcomes and the broader applicability of core stabilization exercises in SIS rehabilitation.

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Conflict of Interest
The authors declare no conflicts of interest

Author Contributions
Idea/Concept: M.O., A.A., & S.F.; **Design:** M.O., A.A., A.N., & S.F.; **Supervision/Consultancy:** A.A., A.N., & S.F.; **Data Collection/Processing:** M.O., & A.A.; **Analysis/Interpretation:** M.O., A.A., A.N., & S.F.; **Manuscript Writing:** M.O., & A.N.; **Critical Review:** A.A., A.N., & S.F.; **Sources/Funding:** M.O., & A.A.; **Materials:** M.O., A.A., & S.F.

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REFERENCES

Al Dajah, S. B. Soft tissue mobilization and PNF improve range of motion and minimize pain level in shoulder impingement. J Phys Ther Sci. 2014;26(11):1803–1805.

Aggarwal, A., Kumar, S., Madan, R., Kumar, R. Relationship among different tests of evaluating low back core stability. J Musculoskelet Res. 2011;14(2):1250004.

Akuthota, V., Nadler, S. F. Core strengthening. Arch Phys Med Rehabil. 2004;85:S86–S92.

Ayhan, C., Unal, E., Yakut, Y. Core stabilisation reduces compensatory movement patterns in patients with injury to the arm: A randomized controlled trial. Clin Rehabil. 2014;28(1):36–47.

Biering-Sørensen, F. Physical measurements as risk indicators for low-back trouble over a one-year period. Spine (Phila Pa 1976). 1984;9(2):106–119.

Borghuis, J., Hof, A. L., Lemmink, K. A. The importance of sensory-motor control in providing core stability. Sports Med. 2008;38(11):893–916.

Bumin, G., Tüzün, E. H., Tonga, E. The Shoulder Pain and Disability Index (SPADI): Cross-cultural adaptation, reliability, and validity of the Turkish version. J Back Musculoskelet Rehabil. 2008;21(1):57–62.

Çakmak, A. Conservative treatment in subacromial impingement syndrome. Acta Orthop Traumatol Turc. 2003;37(1):112–118.

Çitaker, S., Taşkiran, H., Akdur, H., Arabaci, Ü. Ö., Ekici, G. Comparison of the mobilization and proprioceptive neuromuscular facilitation methods in the treatment of shoulder impingement syndrome. Pain Clin. 2005;17(2):197–202.

Chan, E. W. M., Hamid, M. S. A., Nadzalan, A. M., Hafiz, E. Abdominal muscle activation: An EMG study of the Sahrmann five-level core stability test. Hong Kong Physiother J. 2020;40(2):89–97.

Cohen, J. Statistical power analysis for the behavioral sciences. Acad Press. 1977.

Godges, J. J., Mattson-Bell, M., Thorpe, D., Shah, D. The immediate effects of soft tissue mobilization with proprioceptive neuromuscular facilitation on glenohumeral external rotation and overhead reach. J Orthop Sports Phys Ther. 2003;33(12):713–718.

Granacher, U., Lacroix, A., Muehlbauer, T., Roettger, K., Gollhofer, A. Effects of core instability strength training on trunk muscle strength, spinal mobility, dynamic balance, and functional mobility in older adults. Gerontology. 2013;59(2):105–113.

Haas, R., Gorelik, A., Busija, L., O'Connor, D., Pearce, C., Mazza, D., Buchbinder, R. Prevalence and characteristics of musculoskeletal complaints in primary care: An analysis from the POLAR database. BMC Prim Care. 2023;24(1):40.

Harrington, S., Meisel, C., Tate, A. A cross-sectional study examining shoulder pain and disability in Division I female swimmers. J Sport Rehabil. 2014;23(1):65–75.

Hodges PW, Richardson CA. Feed forward contraction of transversus abdominis is not influenced by the direction of arm movement. Exp Brain Res. 1997 Apr;114(2):362-70.

Hodges PW, Richardson CA. Relationship between limb movement speed and associated contraction of the trunk muscles. Ergonomics. 1997 Nov;40(11):1220-30.

Hodges PW. Lumbopelvic stability: a functional model of the biomechanics and motor control. In: Richardson CA, Hodges PW, Hides JA, editors. Therapeutic exercise for Lumbopelvic stabilization. 2nd ed. Edinburgh: Churchill Livingstone; 2004. p. 13–28.

Hodgetts CJ, Leboeuf-Yde C, Beynon A, Walker BF. Shoulder pain prevalence by age and within occupational groups: a systematic review. Arch Physiother. 2021 Nov 4;11(1):24. doi: 10.1186/s40945-021-00119-w

Hazar, Z., Ulug, N., Yuksel, I. Is there a relation between shoulder dysfunction and core instability? Open J Sports Med. 2014;2(11 Suppl 3):2325967114S00173.

Kahle, N. L., Gribble, P. A. Core stability training in dynamic balance testing among young, healthy adults. Athl Train Sports Health Care. 2009;1(2):65–73.

Kendall, F. P. Muscles: Testing and function with posture and pain. Lippincott Williams & Wilkins. 2005.

Kibler, W. B., Press, J., Sciascia, A. The role of core stability in athletic function. Sports Med. 2006;36(3):189–198.

Lucas, J., van Doorn, P., Hegedus, E., Lewis, J., van der Windt, D. A systematic review of the global prevalence and incidence of shoulder pain. BMC Musculoskelet Disord. 2022;23(1):1073.

Lewis, J. S., Green, A., Wright, C. Subacromial impingement syndrome: the role of posture and muscle imbalance. J Shoulder Elbow Surg. 2005;14(4):385–392.

Lust, K. R., Sandrey, M. A., Bulger, S. M., Wilder, N. The effects of 6-week training programs on throwing accuracy, proprioception, and core endurance in baseball. J Sport Rehabil. 2009;18(3):407–426.

MacDermid, J. C., Solomon, P., Prkachin, K. The Shoulder Pain and Disability Index demonstrates factor, construct, and longitudinal validity. BMC Musculoskelet Disord. 2006;7:12.

Matsen, F. A., Arntz, C. T., Lippitt, S. B. Rotator cuff. In: Rockwood CA, editor. The Shoulder. Vol. 2. 2nd ed. Philadelphia: W.B. Saunders; 1998:755–839.

McRoberts, L. B., Cloud, R. M., Black, C. M. Evaluation of the New York Posture Rating Chart for assessing changes in postural alignment in a garment study. Clothing Textiles Res J. 2013;31(2):81–96.

Michener, L. A., McClure, P. W., Karduna, A. R. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. Clin Biomech (Bristol, Avon). 2003;18(5):369–379.

Mısırlıoğlu, T. Ö., Eren, İ., Canbulat, N., Çobanoğlu, E., Günerbüyük, C., Demirhan, M. Does a core stabilization exercise program have a role on shoulder rehabilitation? A comparative study in young females. Turk J Phys Med Rehabil. 2018;64(4):328–336.

Miyake, Y., Kobayashi, R., Kelepecz, D., Nakajima, M. Core exercises elevate trunk stability to facilitate skilled motor behavior of the upper extremities. J Bodyw Mov Ther. 2013;17(3):259–265.

Moezy, A., Sepehrifar, S., Dodaran, M. S. The effects of scapular stabilization-based exercise therapy on pain, posture, flexibility, and shoulder mobility in patients with shoulder impingement syndrome: A controlled randomized clinical trial. Med J Islam Repub Iran. 2014;28:87.

Moreside, J. M., Vera-Garcia, F. J., McGill, S. M. Trunk muscle activation patterns, lumbar compressive forces, and spine stability when using the Bodyblade. Phys Ther. 2007;87(2):153–163.

Mughrabi, M., Alwani, A., Amein, N. The effectiveness of exercise on function for adults with shoulder impingement syndrome (SIS): A structured literature review. IOSR J Sports Phys Educ. 2017;4(1):57–69.

Nakra, N., Quddus, N., Khan, S. A., Kumar, S., Meena, R. L. Efficacy of proprioceptive neuromuscular facilitation on shoulder function in secondary shoulder impingement. Indian J Ther Rehabil. 2013;20(9):450–458.

Olędzka, M., Jaczewska-Bogacka, J. Effectiveness of proprioceptive neuromuscular facilitation (PNF) in improving shoulder range of motion: A pilot study. Ortop Traumatol Rehabil. 2017;19(3):285–292.

Ostör, A. J., Richards, C. A., Prevost, A. T., Speed, C. A., Hazleman, B. L. Diagnosis and relation to general health of shoulder disorders presenting to primary care. Rheumatology (Oxford). 2005;44(6):800–805.

Price, D. D., McGrath, P. A., Rafii, A., Buckingham, B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain. 1983;17(1):45–56.

Ravichandran, H., Janakiraman, B., Gelaw, A. Y., Fisseha, B., Sundaram, S., Sharma, H. R. Effect of scapular stabilization exercise program in patients with subacromial impingement syndrome: A systematic review. J Exerc Rehabil. 2020;16(3):216–226.

Radwan, A., Francis, J., Green, A., Kahl, E., Maciurzynski, D., Quartulli, A., Schultheiss, J., Strang, R., Weiss, B. Is there a relation between shoulder dysfunction and core instability? Int J Sports Phys Ther. 2014;9(1):8–13.

Senbursa, G., Baltaci, G., Atay, A. Comparison of conservative treatment with and without manual physical therapy for patients with shoulder impingement syndrome: A prospective, randomized clinical trial. Knee Surg Sports Traumatol Arthrosc. 2007;15(7):915–921.

Shinkle, J., Nesser, T. W., Demchak, T. J., McMannus, D. M. Effect of core strength on the measure of power in the extremities. J Strength Cond Res. 2012;26(2):373–380.

Sciascia, A., Cromwell, R. Kinetic chain rehabilitation: A theoretical framework. Rehabil Res Pract. 2012;2012:853037.

Tarnanen, S. P., Ylinen, J. J., Siekkinen, K. M., Mälkiä, E. A., Kautiainen, H. J., Häkkinen, A. H. Effect of isometric upper-extremity exercises on the activation of core stabilizing muscles. Arch Phys Med Rehabil. 2008;89(3):513–521.

Tate, A., Turner, G. N., Knab, S. E., Jorgensen, C., Strittmatter, A., Michener, L. A. Risk factors associated with shoulder pain and disability across the lifespan of competitive swimmers. J Athl Train. 2012;47(2):149–158.

Tse, M. A., McManus, A. M., Masters, R. S. Development and validation of a core endurance intervention program: Implications for performance in college-age rowers. J Strength Cond Res. 2005;19(3):547–552.

Van Dieën, J. H., Luger, T., van der Eb, J. Effects of fatigue on trunk stability in elite gymnasts. Eur J Appl Physiol. 2012;112(4):1307–1313.

Yörükoğlu, A. Ç., Şavkın, R., Büker, N., Alsayani, K. Y. A. Is there a relation between rotator cuff injury and core stability? J Back Musculoskelet Rehabil. 2019;32(3):445–452.

Zhong, Z., Zang, W., Tang, Z., Pan, Q., Yang, Z., Chen, B. Effect of scapular stabilization exercises on subacromial pain (impingement) syndrome: A systematic review and meta-analysis of randomized controlled trials. Front Neurol. 2024;15:1357763.

an Dieën, J. H., Luger, T., van der Eb, J. Effects of fatigue on trunk stability in elite gymnasts. Eur J Appl Physiol. 2012;112(4):1307–1313.

Yörükoğlu, A. Ç., Şavkın, R., Büker, N., Alsayani, K. Y. A. Is there a relation between rotator cuff injury and core stability? J Back Musculoskelet Rehabil. 2019;32(3):445–452.

Zhong, Z., Zang, W., Tang, Z., Pan, Q., Yang, Z., Chen, B. Effect of scapular stabilization exercises on subacromial pain (impingement) syndrome: A systematic review and meta-analysis of randomized controlled trials. Front Neurol. 2024;15:1357763.