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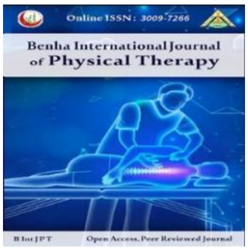

Original research

Correlation of Pain, Function, Muscle Strength, and Proprioception in Shoulder Impingement Syndrome After Strengthening Exercises

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Abstract

Background: Shoulder impingement is a prevalent musculoskeletal issue, with a high incidence rate. Strengthening exercises targeting the scapular stabilizers and rotator cuff muscles have been shown to be an effective treatment approach for shoulder impingement syndrome. **Purpose:** This study aimed to investigate the correlation among pain intensity, shoulder function, isometric muscle strength of the internal and external shoulder rotators, and proprioception in patients with shoulder impingement syndrome after strengthening exercises. **Methods:** An experimental correlation study was conducted involving 15 patients with shoulder impingement syndrome. Pain intensity was assessed using the Visual Analog Scale (VAS), shoulder function was evaluated through the Arabic version of the Shoulder Pain and Disability Index (SPADI), isometric muscle strength of internal and external shoulder rotators was measured using the Lafayette handheld dynamometer, and proprioception was assessed with a digital inclinometer. Patients underwent three weeks of strengthening exercises targeting the rotator cuff muscles and scapular stabilizers. **Results:** Results revealed significant improvement in mean values of VAS, SPADI, HHD, and proprioception in patients with shoulder impingement syndrome after receiving strengthening exercises. Pearson correlation analysis revealed a significant positive correlation between internal and external rotation muscle strength. A significant correlation was found between angle errors at 30° and 120° of shoulder flexion. However, no significant correlation was found between pain intensity, muscle strength, proprioception, and shoulder function. **Conclusion:** Strengthening exercises are effective at improving pain, shoulder function, internal and external muscle strength, and proprioception in SIS patients with no significant correlation between these variables.
Keywords: Muscle Strength, Shoulder Impingement Syndrome, SPADI, Strengthening exercises, VAS

Introduction

Shoulder Impingement Syndrome (SIS) is a prevalent musculoskeletal disorder, affecting a wide range of individuals, particularly those who engage in overhead activities or occupations that involve repetitive shoulder motions[1].

The prevalence of SIS ranges from 7% to 34%, making it the most common cause of

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shoulder pain[1.] SIS is typically characterized by the compression of the rotator cuff tendons which was firstly described by neer in 1972,[2] .particularly the supraspinatus tendon, and other structures within the subacromial space, resulting in pain, weakness, and reduced mobility.

There are two main types of SIS: external impingement and internal impingement. External impingement involves compression of the rotator cuff tendons, particularly the supraspinatus, under the anterior acromion, while internal impingement can involve anterior or posterior types, each associated with contact between the labrum and humeral head [3]. Both forms of impingement can lead to severe shoulder dysfunction, significantly affecting patients' daily activities and quality of life[1,]

Conservative management is widely recognized as an effective initial approach for the treatment of SIS and is commonly utilized to alleviate symptoms, improve function[4]. Rehabilitation exercises aim to improve soft tissue flexibility in addition to exercises that focus on enhancing scapular muscle performance and function[5]. In patients with SIS, exercise therapy has demonstrated compelling evidence of being superior to no treatment or placebo treatment and as effective as surgery in improving shoulder pain, range of motion (ROM), proprioception, mobility, stability, and joint function over the short and long term[6].

One of the most popular therapy approaches for shoulder impingement syndrome is strengthening the glenohumeral (GH) joint's muscles in an effort to restore neuromuscular control[7].

Therapeutic exercises for SIS prove to be as effective as surgical procedure in terms of pain management, function enhancement and improving ROM[6].

Improvement and Recovery of patients with SIS depends on many outcome variables such as pain intensity, functional outcomes, muscle strength, and proprioception[6], but there were no previous studies done to find if there is a correlation between these outcome variables or not.

By investigating the connections between pain, muscle strength, proprioception, and function in patients participating in an organized therapeutic exercise program, this study seeks to close this gap. By evaluating these correlations, this research will help refine rehabilitation strategies and potentially enhance recovery outcomes for SIS patients.

Methods

2.1 Study Design

This is an experimental correlational study designed to analyze the correlation between various dependent variables (pain, shoulder function, muscle strength and proprioception) in patients diagnosed with SIS. The study was conducted at Pharos university in Alexandria and received ethical approval from Ethics Committee, Cairo University with Number (P.T.REC/012/005345). Before being included in the study, each subject gave written informed consent.

2.2 Participants

Fifteen participants (10 men and 5 women) having a clinical diagnosis of Neer's Stage II SIS participated in the study. All of the participants, who ranged in age from 25 to 40, had experienced shoulder pain for at least three months.

Inclusion criteria included[8]:

- Diagnosis of SIS with a positive painful arc during flexion or abduction
- Positive Neer’s, Kennedy-Hawkins,or Empty Can tests
- BMI between 18.5 and 29.9
- No history of cervical radiculopathy, neurological or inflammatory disorders, or previous shoulder surgeries

Exclusion criteria included[8]:

- Cervical radiculopathy symptoms.
- An inflammatory condition was identified.
- A neurological condition.
- Widespread pain problem.
- Evidence of a partial or total rotator cuff injury.
- Frozen Shoulder.
- Patient underwent shoulder surgeries.
- Traumatic Shoulder injuries.

Instrumentation and Procedure of Assessment:

The outcomes were measured pre and post 3 weeks of treatment for each patient as following.

- **Pain Intensity**: The VAS is a simple tool used to assess pain in patients with shoulder impingement syndrome, where individuals mark their perceived pain level on a 100 mm line, with "no pain" at one end and

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"worst possible pain" at the other. The distance between the "no pain" anchor and the patient's mark are then measured to determine the pain score, ranging from 0 to 100. Due to its high sensitivity and reliability, the VAS is widely used to evaluate pain intensity in shoulder impingement syndrome, helping track changes in symptoms over time [9].

- **Shoulder joint Function:** Using Intraclass correlation coefficient (ICC) values for the pain, disability, and total score (ICC, 0.87, 0.96, and 0.95, respectively) of the Arabic version of SPADI were all high, indicating great internal consistency and test-retest reliability. For the assessment of Arabic-speaking patients with shoulder dysfunction, the Arabic SPADI is advised [10].
- **Muscle Strength**: The Lafayette (HHD) was used to assess internal and external shoulder rotation isometric muscle strength. This device is reliable for determining the shoulder's ER and IR strength. The external/internal ratios were reliable in both dominant (ICC 0.80) and non-dominant (ICC 0.81) 50 shoulders, and they were lightweight and portable [11] it has good concurrent validity [12]. Strength values were quantified by measuring the torque produced during the test, divided by the participant's body weight. The participant's moment arm length was measured by the examiner from the olecranon process to a location just in front of the ulna's styloid process. Unilateral shoulder external and internal rotation strength tests were conducted on the afflicted side while the patient was in a prone posture with the elbow bent to 90° and the shoulder abducted 90° and rotated 0° [11]
- **Proprioception**: Assessed using Digital Inclinometer, It has excellent reliability in measurement of shoulder-position sense in the low range of shoulder flexion (55°) and high validity and reliability in all 3 ranges of shoulder flexion (low 55°, mid 90° and high 125°) with ICC = .70 and .60 [13]. Joint Position Sense (JPS) was assessed at 30° and 120° of shoulder flexion using a digital inclinometer. Participants were blindfolded to eliminate visual cues and asked to actively return their arm to the target position [14].

Treatment Procedures

After the patient met the inclusion criteria of our study, they received same exercise program adopted from[15]. The program includes 35–45 minutes of exercise per session, three times a week for 3 weeks each exercise was performed for 3 Sets, 10 Rep and the program consists of five exercises:

- Progression of exercises was done through increasing sets of repetitions and heavier weights according to patients' ten repetition maximum test.

1. Shoulder retraction from standing position with arms beside trunk.
2. Shoulder scaption from standing position.
3. Shoulder external rotation from side lying with a pillow between elbow and trunk.
4. Shoulder protraction from supine position.
5. Shoulder extension from standing position with TheraBand.

All the patients received the exercise program above without adding any therapeutic modality.

2.4 Statistical Analysis

SPSS for Windows, version 26 (SPSS, Inc., Chicago, IL) was used for statistical analysis. The data were checked for the existence of extreme scores, homogeneity of variance, and normality assumption, and the p-value was set at less than 0.05. Descriptive statistics would be used to describe the demographic subject characteristics; in the form of mean and standard deviation (SD) of patients' data (age, weight, height and BMI). Paired T-test would be used for calculating significant difference. The association between each dependent variable was investigated using the Pearson correlation test.

Results

3.1 Descriptive Statistics

Fifteen patients with shoulder impingement syndrome participated in the current study. The distribution of males and females was 66.7 % (10) and 33.3 % (5) respectively. The distribution of dominant and non-dominant sides was 66.7 % (10) and 33.3 % (5) respectively. The mean values of age, weight, height, BMI and duration of symptoms in months for all patients in the group are shown in Table 1.

Table 1: Demographic data

Variable	Mean ± SD
Age (years)	31.8 ± 4.86
Weight (kg)	74.47 ± 11.79
Height (cm)	171 ± 8.8
BMI (kg/m²)	25.4 ± 3.16

The *mean* ± SD of the VAS pre was 6.72±0.848 cm and the VAS post was 4.70±0.593 cm. Independent sample t-test revealed significant differences for the post-intervention assessment of pain intensity ($p< 0.001$*). compared to pre intervention. The mean ± SD of SPADI pre was 92.73±6.670%, and SPADI post was 65±4.796 %. Paired sample t-test revealed significant differences for the post-intervention assessment of functional disability ($p<0.001$*) compared to pre intervention (Table 2).

The mean ± SD of HHD for internal rotation muscles pre was 43.93±7.411, and HHD post was 48.73±8.581. Independent sample t-test revealed significant differences for the post-intervention assessment of Internal rotation muscle strength ($p<0.001$*) compared to pre intervention (Table 4). The mean ± SD of HHD for external rotation muscles pre was 33.67±6.455, and HHD post was 37.60±7.405. Independent sample t-test revealed significant differences for the post-intervention assessment of external rotation muscle strength ($p<0.001$*) compared to pre intervention (Table 2).

The mean ± SD of the Proprioception (AOE at 30 degrees**)** pre was 9.8±2.366 and the post was 8.13±1.995. Independent sample t-test revealed significant differences for the post-intervention assessment of Proprioception at 30 degrees ($p< 0.001$*). compared to pre intervention. The mean ± SD of Proprioception (AOE at 120 degrees) pre was 14.27±2.492, and post was 11.20±1.740. Independent sample t-test revealed significant differences for the post-intervention assessment of Proprioception at 120 degree ($p<0.001$*) compared to pre intervention (Table 2).

Table 2: showing the result of outcome variables pre and post treatment.

Descriptive Statistics			
Variable	**Pre** $\bar{X}$ **± SD**	**Post** $\bar{X}$ **± SD**	**N**
VAS	6.72±0.848	4.70±0.593	15
INT ROT	43.93±7.411	48.73±8.581	15
EXT.ROT	33.67±6.455	37.60±7.405	15
Angle of error at 30	9.8±2.366	8.13±1.995	15
Angle of error at 120	14.27±2.492	11.20±1.740	15
SPADI	92.73±6.670	65.0±4.796	15

3.2 Correlation Analysis

Pearson’s correlation analysis revealed the following significant relationships between the variables:

Correlation analysis between pain and other variables:

No correlation was observed between pain intensity and functional disability, internal and external rotation Power and angle of errors at both 30 and 120 degrees as shown in figure 1-2 and Table 3

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Table 3:presents the Pearson correlation matrix for all assessed variables

Correlations							
		VAS post	INT ROT post	EXT.ROT post	Angle of error at 30 post	Angle of error at 120 post	SPADI post
VAS post	Pearson Correlation	1	-.073	.071	-.044	-.124	.232
	Sig. (2-tailed)		.796	.802	.877	.660	.406
	N	15	15	15	15	15	15
SPADI post	Pearson Correlation	.232	-.491	-.211	-.254	.445	1
	Sig. (2-tailed)	.406	.063	.450	.361	.096	
	N	15	15	15	15	15	15

Significant correlations ($p < 0.05$) are denoted by asterisks

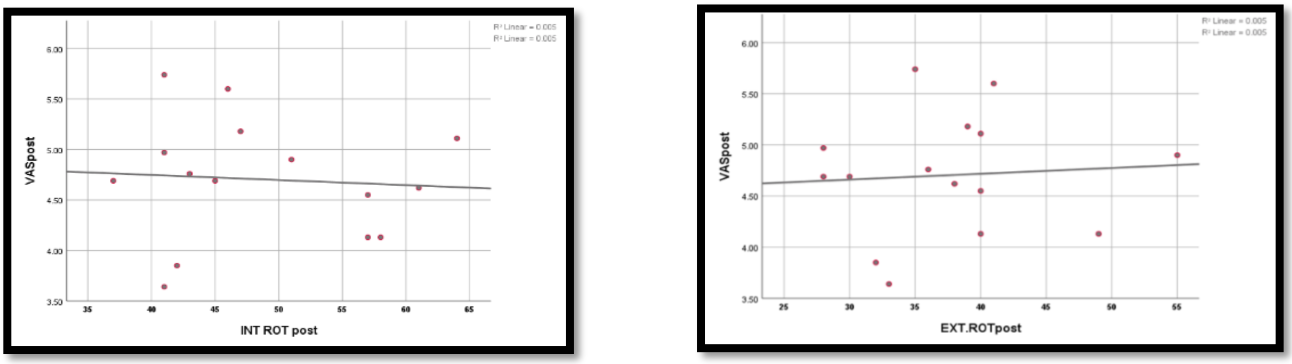

Figure 1: Scatter plot for the correlation between VAS and internal (left) and external (right) rotation Power

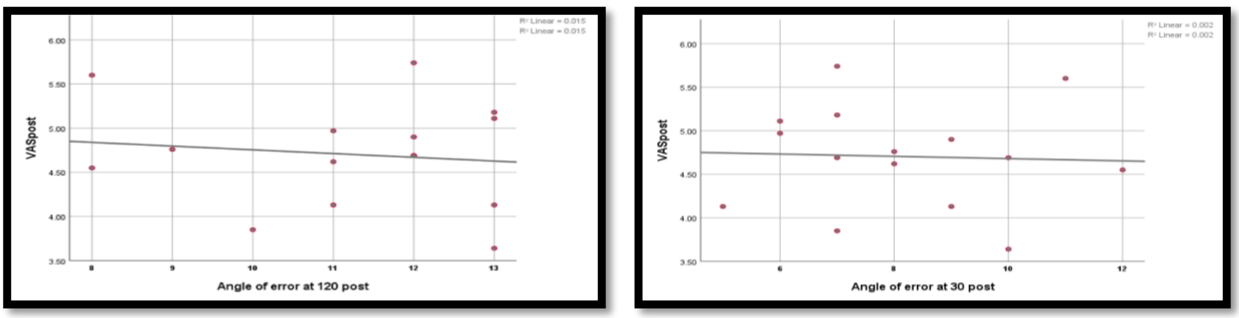

Figure 2: Scatter plot for the correlation between VAS and AOE 30 (left), and 120(right**)**

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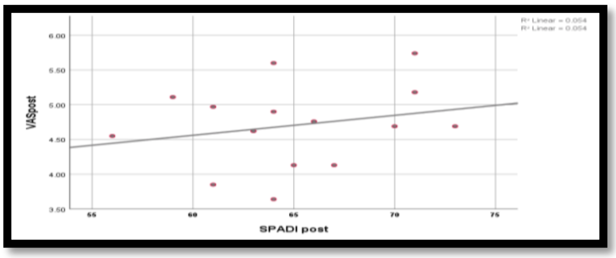

Figure 3: Scatter plot for the correlation between VAS and Functional disability.

Pearson correlation analysis revealed a strong positive correlation between values of internal and external rotation Power (r = 0.581; p = 0.023). On the other hand, no significant correlation was observed between the internal rotation Power and AOE at 30 and 120 degrees (Table 3, Figure 4,5)

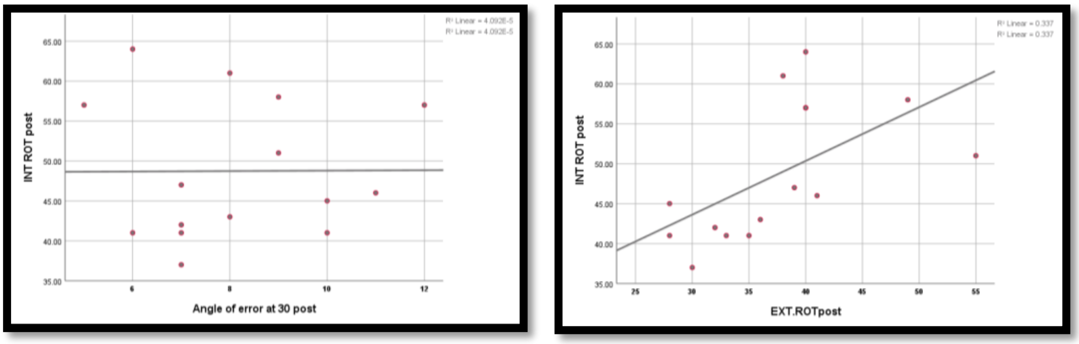

Figure 4: Scatter plot for the correlation between Internal and external rotation Power (left) and AOE30 (right).

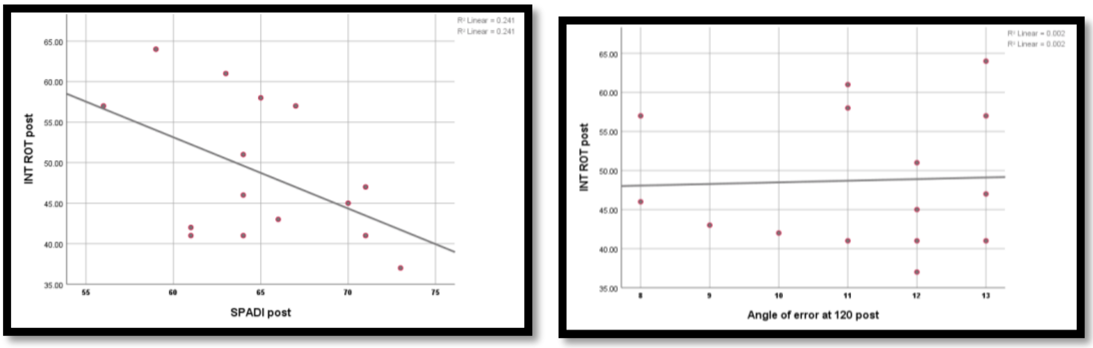

Figure 5: Scatter plot for the correlation between and AOE 120 (left), and functional disability (right).

Pearson correlation analysis revealed no correlation between values of external rotation Power and AOE at both 30 and 120 degrees in addition to functional disability (Table 3, Figure 6).

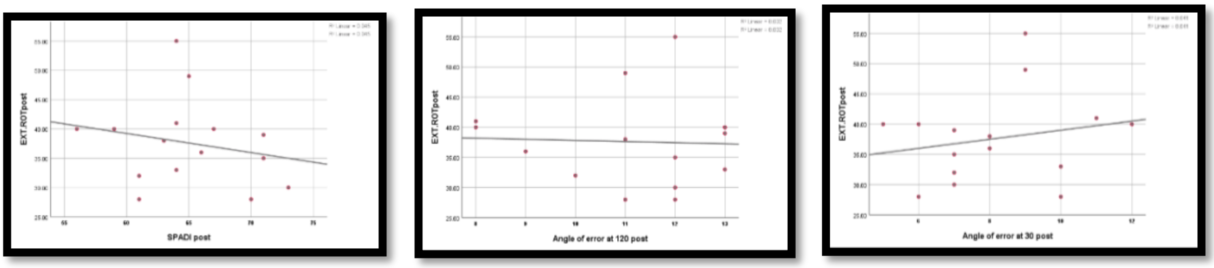

Figure 6: Scatter plot for the correlation between External rotation Power and AOE 30 (left), AOE 120 (middle), and Functional disability (right).

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Pearson correlation analysis revealed a significant strong correlation between values of AOE at 30 and 120 degrees (r = 0.564; *p* = 0.029). On the other hand, no significant correlation was found between AOE at both 30 and 120 and functional disability (Table 3, Figure 7).

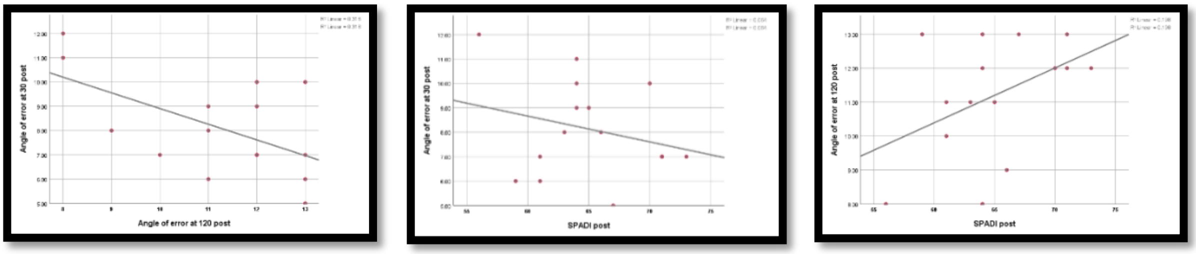

Figure 7: Scatter plot for the correlation between AOE 30 and AOE 120 (left), and functional disability (middle), and between AOE 120 and functional disability (right).

Discussion

The results of this study demonstrated significant improvements in VAS, SPADI, HHD, and proprioception following strengthening exercises compared to pre-treatment values, highlighting their effectiveness in managing SIS. The substantial reduction in mean VAS scores indicates that targeted strengthening exercises contribute to pain relief, while the improvement in SPADI scores reflects enhanced shoulder function and reduced disability. Additionally, increased internal and external muscle strength, as measured by HHD, reinforces the role of strengthening exercises in enhancing rotator cuff performance. Furthermore, the reduction in proprioceptive errors at 30° and 120° suggests that proprioception training was effective in improving neuromuscular control of the shoulder.

Improvement in Pain:

The significant decrease in VAS scores after the intervention aligns with previous research supporting the role of strengthening exercises in pain reduction. Haik et al.,[6] and Kuhn[16] demonstrated that strengthening exercises for SIS patients effectively alleviate pain by improving muscular support around the shoulder joint, reducing subacromial compression, and enhancing scapulohumeral rhythm. Our study corroborates these findings, indicating that a well-structured strengthening program helps relieve pain by restoring proper joint biomechanics.

Improvement in Function:

Our study showed significant improvements in SPADI scores post-intervention, indicating enhanced shoulder function and reduced disability. These results are consistent with McClure et al[17], who found that a six-week exercise program which is similar to our program improved scapular muscle activation patterns, leading to better shoulder mechanics and reduced functional limitations. Haik et al [6] .also emphasized that exercise therapy is as effective as surgical intervention in improving shoulder mobility and function in SIS patients.

Improvement in Muscle Strength:

The significant increase in internal and external rotator strength observed in our study aligns with previous research by Ellenbecker & Cools[5], who demonstrated that targeted strengthening exercises improve rotator cuff performance, leading to enhanced shoulder function and reduced injury risk. Similarly, MacDermid et al[18], found a strong relationship between rotator cuff pathology and isometric external rotation strength, emphasizing the importance of maintaining adequate muscle strength to support shoulder mechanics. The improvement could be explained as strengthening exercises improve muscle performance through neuromuscular adaptations, including increased motor unit recruitment, improved coordination between agonist and antagonist muscles, and enhanced muscle fiber hypertrophy.

The highly positive correlation between internal and external rotation muscle strength indicates that the changes in the strength of one direction of rotational strength are connected to the changes in the other. This supports the theory that strengthening programs for the rotator cuff muscles

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are accountable for overall shoulder function and stability. Similar findings were provided by Holmgren et al.,[19] who demonstrated that a progressive resistance exercise program improved internal and external rotation strength in patients with SIS. Given the significant role played by the rotator cuff in glenohumeral joint stability, which show us the importance for the inclusion of the strengthening exercises in rehabilitation programs for SIS patients, which is similar to our specific targeted strengthening exercises, reinforcing the importance of targeted rehabilitation [5,19].

The findings of current study align with those of MacDermid et al 18who identified a strong relationship between rotator cuff pathology and muscle strength, particularly isometric external rotation, as the most significant predictor of lower shoulder function scores on the SPADI questionnaire. Their study, like ours, highlighted the association between reduced isometric muscle strength and increased functional limitations and pain in SIS patients. Additionally, they evaluated the reliability of different strength measurements, concluding that isometric strength assessments were more dependable than concentric and eccentric measures in correlating with shoulder function. A further point of similarity between our studies is the inclusion of SIS patients and the use of SPADI for functional assessment, reinforcing the importance of isometric strength evaluation in SIS rehabilitation.

Celik & Demirhan[4] disagreed with our findings, using VAS and HHD to find a correlation between anterior deltoid, middle trapezius, serratus anterior, and supraspinatus muscle weakness and pain. This discrepancy may be because we only evaluated the internal and external rotators of the shoulder joint

Improvement in proprioception :

The improvement in proprioception post treatment, as measured by angle of error at 30° and 120° of shoulder flexion, is due to enhanced neuromuscular control. These findings are supported by Gumina et al[14], who demonstrated that proprioception training effectively reduces repositioning errors and improves joint stability. Additionally, Ager et al.,[20] suggested that sensorimotor deficits in SIS patients are primarily due to faulty integration of proprioceptive feedback rather than strength deficiencies alone, highlighting the importance of proprioceptive training alongside strengthening exercises. The improvements in proprioception observed in our study can be attributed to increased sensory input from mechanoreceptors in the muscles and joint capsules, leading to enhanced afferent feedback and motor control. Strengthening exercises stimulate proprioceptive pathways by promoting co-contraction of stabilizing muscles, reducing excessive joint play, and improving movement accuracy.

Additionally, proprioception at 30° and 120° showed a significant correlation, indicating the importance of strengthening training to enhance shoulder stability and Proprioception. Gemina et al[14], agreed with our results where they also tested the angle of error in the same degrees at 30° and 120° using also active repositioning as a method of testing, which proves that proprioception is one of the essential component of treatment program which can be improved by strengthening exercise program.

Although our study found a significant reduction in VAS scores following strengthening exercises, some studies suggest that exercise alone may not be the most effective strategy for pain relief. Kuhn [16] in a systematic review, reported that while strengthening exercises can help in SIS rehabilitation, they may not be superior to other interventions such as manual therapy, corticosteroid injections, or combined treatment approaches. Similarly, Haik et al[6] found that patients who received both strengthening exercises and manual therapy experienced greater pain relief compared to those who performed strengthening exercises alone. One possible explanation for this discrepancy is that pain in SIS is not solely related to muscle weakness but is also influenced by factors such as inflammation, joint stiffness, and neural sensitization, which may not be fully addressed by strengthening exercises alone.

In our study pain intensity did not correlate with muscle strength, proprioception, or functional outcomes. This is consistent with McClure done in 2004[17], which suggested that functional recovery in SIS patients may depend more on neuromuscular adaptations than on pain reduction, reinforcing the argument that pain relief alone does not necessarily lead to functional improvement, they used (3-dimensional kinematic patterns, thoracic posture, muscle force, and motion) to find the correlation

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between these variables. These results support the results of our study where improvement in pain intensity doesn't always correlate with significant improvement in function, muscle strength nor proprioception.

Ager et al[20] agreed with our results as concluded, based on the Disability of Arm, Hand, and Shoulder (DASH) questionnaire, that proprioceptive deficits in SIS patients are primarily due to impaired sensorimotor integration rather than muscle weakness. Their study also utilized secondary outcome measures, including the Western Ontario Rotator Cuff (WORC) Index, resting pain levels, and maximum isometric voluntary contractions (MIVC), to explore the relationship between function, proprioception, and muscle strength. They emphasized that effective rehabilitation should incorporate both strengthening and proprioceptive exercises to achieve optimal recovery. Although their study employed different assessment tools than ours, our findings align, underscoring the importance of a comprehensive rehabilitation approach for SIS patients.

Conclusion

This study highlights the benefits of strengthening exercises in the rehabilitation of shoulder impingement syndrome. The results indicate that targeted exercise interventions effectively improve shoulder function, enhance muscle strength, and refine proprioceptive control. However, no relationship was found between pain intensity and muscle strength, proprioception, or overall shoulder function .

Recommendations

Establishing causal links between the variables is limited by the cross-sectional approach. A more thorough knowledge of how alterations in muscle strength, proprioception, and pain severity over time support functional recovery in SIS patients would be possible with longitudinal investigations. Future research should also explore the effectiveness of rehabilitation protocols that integrate both strengthening and proprioceptive training to optimize recovery outcomes.

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