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The effect and permanence of corrective exercises on pain intensity, functional disability and kinematic parameters of bodybuilders with shoulder impingement syndrome

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Abstract

Background: Shoulder impingement syndrome is a common complication that causes pain and disability, functional limitations and reduced quality of life. This syndrome is usually seen in people who are involved in activities and sports involving rotating movements above the head, including bodybuilders. Meanwhile, corrective exercises have been considered as an intervention in the rehabilitation of the condition. Exercises based on National Academy of Sports Medicine (NASM) principles are known as one of the new methods in the rehabilitation and prevention of sports injuries.

Aim: The purpose of this study was to investigate the effect and permanence of corrective exercises on pain intensity, functional disability and kinematic parameters of bodybuilders with shoulder impingement syndrome.

Materials and Methods: In this semi-experimental research with a pre-test-post-test design, 20 male bodybuilders with shoulder impingement syndrome were randomly assigned in two groups; corrective exercises as the experimental group (n=10) and control group (n=10). Visual Analog Scale (VAS) questionnaire was used for pain intensity. Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire was used for functional disability. Kinovea software was used to kinematic parameters. The evaluations carried out during three stages: the pre-test, the first post-test (after 8 weeks) and the second post-test (after 12 weeks). Data were analyzed using descriptive statistics, repeated measures analysis of variance (ANOVA) at a significance level of 0.05 using SPSS version 20 software.

Results: The findings showed that after 8 weeks of corrective exercises, there were significant changes in pain intensity and functional disability in the experimental group ($P<0.05$). Also, significant changes in shoulder biomechanical parameters during flexion, abduction, external rotation and internal rotation movements were observed between the two groups ($P<0.05$). Permanence of the exercises in the studied variables after 12 weeks showed a significant difference between the two groups ($P<0.05$).

Conclusion: According to the obtained results, it can be stated that a course of NASM exercises reduced shoulder pain, improved functional disability and improved kinematic parameters in male bodybuilders with shoulder impingement syndrome.

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1. Introduction

In bodybuilding, one of the most important goals is to increase muscle strength, and mass and determine body shape [1]. Bodybuilders enter this field with the primary goals of enhancing their overall health, increasing strength, and improving their physical fitness. Some also aspire to compete in bodybuilding competitions. However, it's noteworthy that many athletes who focus on weightlifting to boost their strength tend to concentrate on developing muscles like the pectorals, deltoids, and abdominals, while often overlooking the importance of strengthening the muscles responsible for stabilizing the scapulothoracic and glenohumeral joints [2]. This discrepancy in muscle development can result in weaknesses within the scapular stabilizers and rotator cuff muscles [2].

Notably, the shoulder joint is particularly susceptible to injuries and is often cited as one of the most commonly affected areas of the body [3]. Imbalances in strength can lead to suboptimal scapulohumeral rhythm during shoulder elevation, potentially contributing to shoulder impingement [4]. Moreover, repetitive and heavy use of the shoulder complex throughout a full range of motion, as seen in exercises like bench presses, overhead press and dumbbell flyes, can increase the risk of shoulder dynamic instability, impingement, and even rotator cuff tears [5].

Additionally, certain common shoulder resistance exercises, such as those that involve end-range external rotation, place excessive stress on the shoulder joint, making it susceptible to both acute and chronic injuries [2, 3, 6]. Shoulder injuries are prevalent in sports that involve repetitive overhead movements. These injuries encompass labrum tears, rotator cuff tears, and biceps muscle injuries, which are frequently observed in various weightlifting disciplines. Sports that entail substantial physical contact, collisions, and falls are often associated with fractures [7].

Notably, a study by Siewe et al. (2014) revealed that approximately 45.1% of bodybuilding athletes experience symptoms of shoulder injuries during their training [8]. Moreover, epidemiological reports from the United States indicate a prevalence of shoulder joint injuries ranging from 22% to 36% [3].

Meanwhile, shoulder impingement syndrome accounts for 44-65% of shoulder complaints. The functional type of this syndrome is caused by muscle weakness or imbalance [9, 10, 11, 12]. When the humerus has up to 90 degrees of abduction with 45 degrees of internal rotation, the rotator cuff, the long head of the biceps tendon and the subacromial bursa under the coracoacromial ligament have the most compression and inflammation [13]. Compared to normal people, patients with impingement show more proximal movement of the humeral head during abduction, so their subacromial space is reduced [10, 14]. Finally, apart from examining things like functional disability and movement kinematics, it will be very important to pay attention to the prevalence of pain and complaints in bodybuilders and plan to reduce such pain. Pain during training is a very common issue in bodybuilding and can hinder the progress and performance of bodybuilders. Pain attacks bodybuilders in many different patterns during training. The shoulder complex with 12.7% is the most common location of pain in the upper limb [8].

In recent years, various exercise protocols for addressing shoulder injuries have been proposed in the literature [15, 16, 17, 18, 19, 20]. These studies typically underscore the importance of enhancing flexibility through stretching and improving muscle strength and endurance through resistance exercises. The National Academy of Sports Medicine (NASM) advocates a comprehensive approach to exercise effectiveness, incorporating four key techniques: inhibition, lengthening, activation, and coherence [21, 22, 23, 24].

In this protocol, restraint exercises are prioritized for hyperactive muscles before engaging in stretching exercises. The myofascial release technique involves self-stimulation of specific receptors by applying sustained pressure with precise intensity, quantity, and duration. This pressure is administered either with high intensity for a short duration of 30 sec (at the threshold of maximum pain tolerance) or low intensity for an extended period of 90 sec (at the minimum pain tolerance level) [25].

For less active muscles, it is recommended to conclude the regimen with cohesion exercises, rather than solely focusing on strengthening [22]. The absence of a program adhering to these principles specifically designed for bodybuilders dealing with impingement syndrome prompted the researcher to investigate the impact and long-term effectiveness of a corrective exercise program based on NASM principles.

The study aimed to evaluate its effects on pain intensity, functional disability, and kinematic parameters of the shoulder joint in bodybuilders suffering from impingement syndrome.

2. Materials and Methods

2. 1. Participation

This research was conducted among intermediate to professional bodybuilders in Khorramabad city, with at least 4 years of sports experience, ages of 25-35 years and shoulder impingement syndrome. To determine the sample size, G-Power software was utilized for a repeated measures analysis of variance, with a power of 0.95, alpha level of 0.05, and an effect size of 0.50. This calculation yielded a required sample size of 14 participants for two groups.

To account for potential dropout of subjects, 20 individuals were randomly selected and divided into two groups: an experimental group consisting of 10 participants and a control group with 10 participants. Before commencing the testing, a comprehensive explanation of the research process, conditions, task complexity, and potential risks was provided to all participants. They were asked to complete informed consent forms, confirming their voluntary and informed participation in the study. It was made clear that anyone could withdraw from the study at any point without any obligation to continue (Human Studies Committee code: IR.SSRI.REC.1401.1837).

2. 2. Instrument

The measurements and equipment used in the study included as fallow.

Weight Scale and Height Gauge: Seca model 755, manufactured in Germany, with a precision of 500 grams and the capability to measure height and weight up to 200 kg.

Pain Assessment: Visual Analog Scale (VAS) questionnaire, which exhibited a reliability coefficient of ICC=83% for assessing pain intensity [26].

Functional Disability Assessment: The DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire, which demonstrated a reliability coefficient of 0.96 [27].

Video Recording: A Samsung digital camera with 25 megapixels, manufactured in Korea, featuring a frame rate of 30 frames per second (fps) and HDR imaging for video recording purposes.

Kinematic Analysis: Kinovea software, version 0.8.15, known for its high reliability with a coefficient of 0.98 [28], for evaluating various kinematic parameters [29, 30, 31].

2. 3. Procedure

The current research was semi-experimental with a pre/post-test design and was of applied type. The research included 20 male bodybuilders who had been diagnosed with shoulder impingement syndrome and met the following criteria: A history of experiencing anterior or lateral shoulder pain within the past six months, with episodes lasting more than one week. The presence of painful arch symptoms during active shoulder elevation. Tenderness upon palpation of the rotator cuff tendon. Pain experienced during isometric shoulder abduction against resistance. A positive result in at least one of the subacromial impingement tests, such as the Neer and Hawkins tests [32, 33, 34].

Individuals with any of the following conditions were excluded from the study: A history of dislocation, fracture, or traumatic injuries involving the shoulder complex, recent shoulder surgery within the last six months, occurrence of neck pain during testing, inability to complete the test sessions, complete rupture of the rotator cuff muscles accompanied by acute shoulder inflammation [34].

Following the initial screening, demographic information of the bodybuilders, including age, height, and weight, was recorded (Table 1).

Table1. Demographic information of both group and independent t-test of

Indicator	Group	N	Mean ± SD	T	*P*
Age (years)	Experimental	10	30.4 ± 3.27	0.713	0.519
	Control	10	29.80 ± 3.88		
Height (cm)	Experimental	10	176.01 ± 4.47	0.518	0.537
	Control	10	174.80 ± 5.80		
Weight (kg)	Experimental	10	86.02 ± 5.53	0.657	0.548
	Control	10	84.80 ± 6.33		

Subsequently, the subjects' pain levels were assessed using a visual pain scale and their shoulder's functional disability was evaluated through the arm, shoulder, and hand disability measurement questionnaire.

To analyze the kinematic parameters of the shoulder joint, including angular displacement and angular velocity, videography and Kinovea software [31] were employed during flexion, abduction, internal rotation, and external rotation movements [28]. The camera was positioned at a distance of 1.5 m from the subjects, mounted on a tripod at a height of 80 cm to capture both sagittal and frontal views of the affected shoulder [28]. Each test was conducted three times, and the average values were utilized for subsequent statistical analysis.

All assessments were conducted at three stages: pre-test, first post-test, and second post-test. The experimental group adhered to the exercise protocol for duration of 8 weeks, while the control group continued their daily activities. To assess the sustained effects of the exercises, a second post-test was administered to subjects in both groups four weeks after the first post-test [35]. During this period, the experimental group resumed their regular daily activities between the first and second post-tests.

2. 4. Exercise protocol

The training program spanned 8 weeks, with each week comprising three one-hour sessions. Each session was divided into three segments: warm-up (10 min), the main program (45 min), and cooling-down (5 min).

The warm-up phase encompassed essential shoulder movements, such as pendular and rotational exercises.

The primary program was structured into four phases: inhibition, lengthening, activation, and coherence. The protocol was designed in such a way that in the initial weeks, the foundational techniques of inhibition and lengthening had a greater emphasis compared to other exercises. However, as the training progressed, subjects became more proficient, and activation and coherence techniques were incorporated more prominently.

The cooling-down phase involved walking and relaxation movements.

All exercises were conducted in the afternoon, with a brief 10-sec rest period between each exercise [21].

2. 5. Statistic

Descriptive statistics, including the mean and standard deviation, were utilized to summarize the collected data. The normality of the variables was assessed using the Kolmogorov-Smirnov test. To compare the means of the two groups at the pre-test stage, an independent t-test was employed.

Subsequently, after verifying the necessary assumptions, repeated measures analysis of variance (ANOVA) was conducted to examine several factors: within-group variation over time (with three levels: pre-test, post-test 1, and post-test 2), between-group differences (with two levels: experimental and control groups), and the interaction effect between group and time. The significance level for these analyses was set at 0.05. All statistical analyses were carried out using SPSS version 25 software.

3. Results

The demographic information of the subjects is reported in Table 1. Independent t-test was used to show no difference between groups in age, height and weight index ($P>0.05$).

Table 2 presents the mean and standard deviation of the examined variables, including pain, functional disability, angular displacement (θ), and velocity (ω) during flexion (F), abduction (AB), external rotation (ER), and internal rotation (IR) movements. The results of the repeated measures composite analysis of variance revealed that the group*time interaction had a significant effect on all variables: pain, functional disability, and biomechanical parameters ($P=0.001$). The effect of time was significant within the experimental group ($P=0.001$).

Post-hoc Bonferroni tests conducted for the experimental group demonstrated significant differences between the pre-test and post-test 1, as well as between the pre-test and post-test 2 ($P<0.05$). However, there was no significant difference between post-test 1 and post-test 2 ($P>0.05$). This indicates that, following 8 weeks of exercise intervention, the experimental group experienced reductions in pain and functional disability, along with increases in angular displacement, and these effects were still present after 4 weeks of non-training ($P>0.05$). As depicted in Figure 1 (a to d), the effect of the group was also significant, signifying that significant differences between the control and experimental groups in terms of pain, functional disability, angular displacement, and velocity were observed after both 8 and 12 weeks ($P<0.05$).

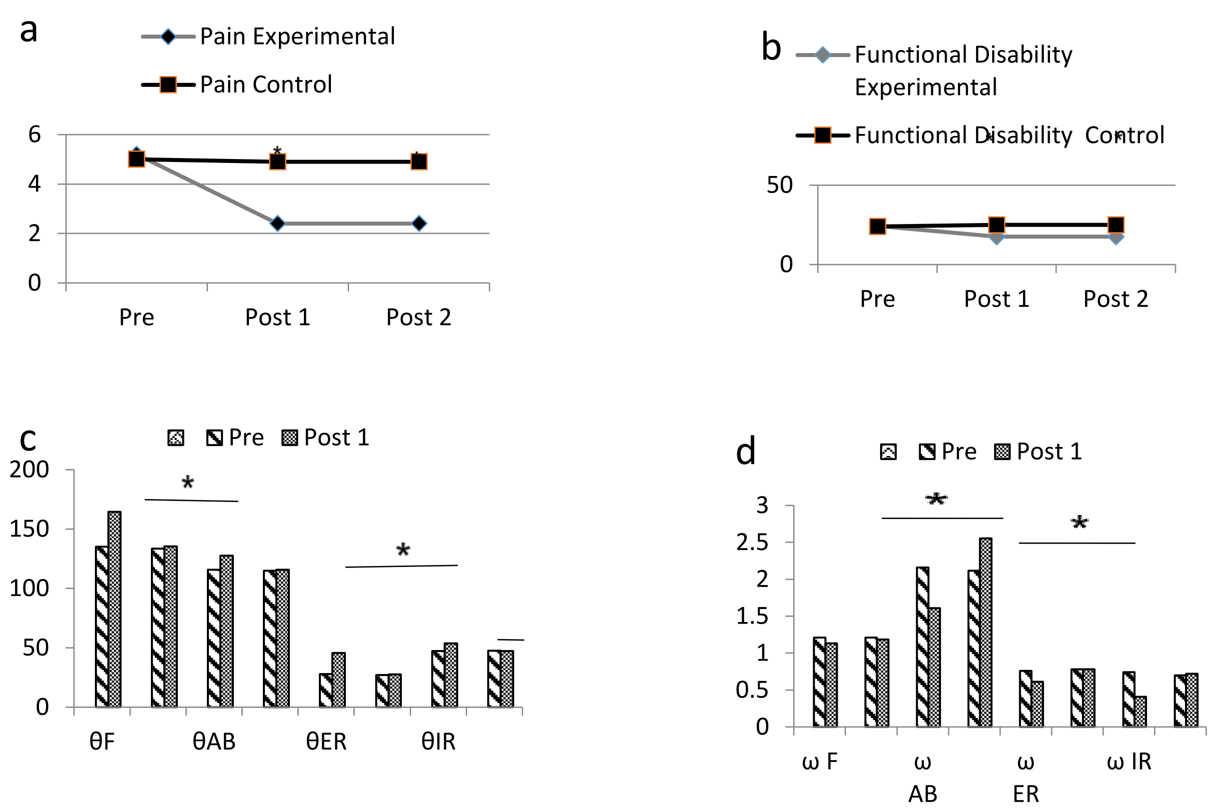
4. Discussion

The aim of this study was to investigate the effect and permanence of corrective exercises on pain intensity, functional disability, and kinematic parameters among bodybuilders suffering from shoulder impingement syndrome. The research findings revealed that an 8-week corrective exercise program led to a reduction in both pain intensity and functional disability among bodybuilders with shoulder impingement syndrome.

Table 2. Repeated measures analysis of variance (ANOVA) in two groups (experimental n=10, control n=10)

Variable		Group	Time						Time effect
			Pre		Post 1		Post 2		
			Mean	SD	Mean	SD	Mean	SD	
Pain		Experimental	5.20	0.33	2.40	0.20	2.40	0.20	0.001*[a,b]
		Control	5.00	0.33	4.90	0.20	4.90	0.20	0.823
		Group effect	0.673		0.001*		0.001*		0.001*
Functional disability		Experimental	24.30	0.63	17.60	0.40	17.60	0.55	0.001*[a,b]
		Control	24.00	2.00	25.00	2.70	25.00	2.15	0.243
		Group effect	0.741		0.001*		0.001*		0.001*
Angular displacement	θ F	Experimental	135.00	1.03	164.60	0.653	164.60	0.653	0.001*[a,b]
		Control	133.60	1.077	135.50	1.078	135.40	1.056	0.177
		Group effect	0.361		0.001*		0.001*		0.001*
	θ AB	Experimental	115.60	0.702	127.70	1.325	128.200	1.153	0.001*[a,b]
		Control	114.80	0.629	115.80	0.757	115.30	0.496	0.138
		Group effect	0.407		0.001*		0.001*		0.001*
	θ ER	Experimental	28.00	0.577	45.70	0.539	45.00	0.577	0.001*[a,b]
		Control	27.10	0.458	27.60	0.427	28.40	0.221	0.638
		Group effect	0.238		0.001*		0.001*		0.001*
	θ IR	Experimental	47.20	0.663	53.80	0.593	54.00	0.650	0.001*[a,b]
		Control	47.60	0.562	47.30	0.559	48.20	0.512	0.217
		Group effect	0.651		0.001*		0.001*		0.001*
Angular velocity	ω F	Experimental	1.212	0.006	1.132	0.006	1.131	0.006	0.001*[a,b]
		Control	1.208	0.006	1.185	0.007	1.183	0.004	0.322
		Group effect	0.654		0.001*		0.001*		0.001*
	ω AB	Experimental	2.159	0.006	1.607	0.006	1.605	0.006	0.001*[a,b]
		Control	2.117	0.016	2.554	0.019	2.067	0.016	0.006*
		Group effect	0.188		0.001*		0.001*		0.001*
	ω ER	Experimental	0.760	0.034	0.610	0.023	0.620	0.033	0.001*[a,b]
		Control	0.780	0.061	0.780	0.053	0.804	0.064	0.259
		Group effect	0.778		0.009*		0.020*		0.001*
	ω IR	Experimental	0.740	0.031	0.408	0.025	0.500	0.026	0.001*[a,b]
		Control	0.700	0.047	0.720	0.053	0.730	0.047	0.604
		Group effect	0.486		0.001*		0.001*		0.001*

*a: t1, t2 (pre-test and the first post-test (after 8 weeks))
*b: t1, t3 (pre-test and the second post-test (after 12 weeks))



* Significant difference between the control and experimental groups in post-test 1 and 2 (*P*<0.05). a) pain, b) functional disability, c) angular displacement, d) angular velocity

Figure 2. Effect of the group in the variables of pain, functional disability, angular displacement and velocity

Furthermore, even after a 4-week period without corrective exercises, participants continued to experience decreased pain levels and lasting improvements in functional disability.

Additionally, following 8 weeks of training, there was a notable increase in angular displacement during flexion, abduction, internal and external rotation movements. This increase was accompanied by a decrease in the angular velocity of these movements. Notably, the positive effects on kinematic parameters persisted even after the 4-week interval, underscoring the significance of their long-lasting impact.

The findings of this study demonstrate that corrective exercises effectively reduce pain intensity and functional disability, and these improvements are sustained over time. This outcome aligns with prior research in the field. Previous studies have shown that exercises focusing on the shoulder [36], as well as stretching and strengthening exercises for the lower back combined with stabilization exercises [37], mobilization with movement [38], and strengthening exercises [39], can ameliorate pain and functional disability in athletes, particularly those suffering from shoulder impingement syndrome.

Similar to the current study, Al-Masoudi et al. (2020) also found that an 8-week implementation of the NASM exercise protocol was an effective method for reducing pain intensity [40]. While they also targeted muscles implicated in shoulder impingement syndrome, their protocol differed from the exercises used in the present study. The reduction in pain may be attributed to the varying loads applied during training, which activate local metabolism, restore it to normal levels, sensitize central receptors, mitigate muscle atrophy, and ultimately reduce pain and functional disability [36]. It appears that the exercises in this study corrected joint misalignment and abnormal muscle tension, leading to the reduction in pain and functional disability.

In the realm of sports, it is crucial to understand whether weak static and dynamic posture, maintaining proper body alignment and repetitive movements can lead to connective tissue disorders in the musculoskeletal system [41, 42, 43]. Dysfunction is often regarded as an injury [41]. It appears that NASM exercises, particularly in the inhibition phase, focus on restraining and relaxing hyperactive muscles, potentially helping to maintain proper body alignment [44]. Karimian et al. (2014) also suggest that preventive techniques likely function by reducing and releasing tension and reducing excessive tissue and muscle activity [24]. Hunten et al. propose that ischemic compression and static stretching may be effective in pain reduction [45]. Corrective movements can address tissue tightness and inconsistency by using lengthening techniques, optimizing the length-tension relationship [46].

Another aspect of the current research shows that after 8 weeks of corrective exercises, there was an increase in angular displacement during flexion, abduction, and internal and external rotation movements, coupled with a decrease in angular velocity. These effects on kinematic parameters persisted after 4 weeks, which is in line with the findings of Chilgar et al. (2020) [47], Kim and Song (2020) [48], and Peteraitis and Smedes (2020) [49]. Some previous studies have utilized home exercises and physiotherapy [50] as well as biofeedback exercises [51], showing that these exercises affect the electrical activity of muscles involved in shoulder impingement syndrome and the range of motion during flexion. These studies suggest that with proper exercises, muscle balance disrupted by the syndrome can be restored [51]. Senbursa et al. (2007) also reported a significant improvement in flexion range of motion due to physical therapy exercises [50].

There is substantial evidence indicating that bodybuilders tend to exhibit reduced shoulder range of motion (ROM), particularly in internal rotation, compared to non-bodybuilders [52]. Additionally, the scapular retraction strength of bodybuilders does not necessarily surpass that of non-bodybuilders. These factors collectively render bodybuilders, who endure heavy weightlifting loads, more susceptible to shoulder injuries [53, 54].

Consequently, the primary focus in corrective exercises should be placed on the muscle groups implicated in upper limb and trunk movements, with the goal of minimizing the likelihood of biomechanical alterations in the shoulder girdle, thereby reducing the risk of shoulder impingement.

The results of this study demonstrated that corrective exercises led to increased range of motion in flexion, abduction, and particularly internal and external rotation. In accordance with our findings, Turgut et al. (2017) also found that shoulder stabilization exercises yielded benefits for individuals with shoulder impingement syndrome, including improvements in external rotation and upper shoulder rotation [37].

Regarding kinematic investigations resulting from corrective exercises, Hosseinimehr et al. (2015) examined shoulder abduction in overhead throwing and noted that at 90 degrees of shoulder abduction, there was an increased upward rotation of the scapula and a significant change in the scapulohumeral rhythm angle from 45 to 90 degrees [54].

Various factors have been cited to explain the biomechanical changes caused by this injury and the reasons for improvement through corrective exercises. These factors include the strengthening and proper function of upper scapular rotators and the restoration of natural scapulothoracic rhythm [55]. Achieving a balance between the lower and middle trapezius muscles, increased scapular mobility, and improved coordination between the scapula and glenohumeral joint have also been highlighted as reasons for improvement following exercises [55].

Karimian et al. (2019) proposed that strengthening weakened muscles leads to biomechanically sound movements and the restoration of proper positions in affected areas [24]. It is plausible that correction and exercise programs designed based on Janda's chain reaction theory and Bruger's gear mechanism contribute to the alleviation of pain, improvement in functional disability, and enhancement of biomechanical parameters in bodybuilders with shoulder impingement syndrome [24, 56, 57, 58, 59, 60].

5. Conclusions

In summary, shoulder pain often stems from factors such as muscle imbalances, postural deviations, and muscle overuse, especially during arm movements like abduction and internal rotation, leading to impingement of the supraspinatus tendon [61]. Consequently, recent research and therapeutic approaches have increasingly emphasized chain reactions and the use of combined exercises, such as NASM exercises, over localized exercises [62]. This shift in focus is due to the recognition that damage in one part of the shoulder can have cascading effects on other areas. Improper kinematic alterations of the scapula can limit the range of motion in the shoulder girdle, potentially leading to injury [63].

The mechanism behind shoulder rehabilitation exercises involves enhancing blood circulation and nourishing the shoulder joint, preventing muscle atrophy, relaxing shoulder muscles, instilling a sense of relaxation and self-confidence in patients, reducing pain in damaged tissues, restoring normal range of motion, increasing displacement, and decreasing angular velocity, all contributing to pain reduction in the shoulder joint [64]. Therefore, the exercise programs implemented in this study were designed with the overarching goal of alleviating pain and disability while increasing the kinematic range of motion of the shoulder joint. Individuals dealing with shoulder impingement syndrome often require rehabilitation exercises to bolster the strength of their shoulder muscles for improved performance [65]. Researchers have concluded that effective rehabilitation exercises should encompass aspects such as muscle balance, endurance, strength, dynamic stability, and neuromuscular control [52]. As such, it appears that NASM exercises can effectively enhance shoulder joint performance by addressing these crucial elements.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc. The participants were informed about the purpose of the research and its implementation stages; they were also assured about the confidentiality of their information. Moreover, they were allowed to leave the study whenever they want, and if desired, the results of the research would be available to them.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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