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Efficacy of Core Stability in Treatment of Patients with Shoulder Impingement Syndrome: Single blinded randomized Controlled Trial

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Abstract:
Purpose: To investigate the impact of core stability exercises on shoulder pain, muscle strength, and function in the non-athletic population with SIS.
Methods: Thirty individuals with SIS were enrolled and randomly allocated to either a control group to obtain traditional physical therapy or an experimental group to receive traditional physical therapy in addition to core stability exercises. The outcomes were pain by visual analogue scale **VAS**, shoulder muscle strength by handheld dynamometer **HHD**, and shoulder function by the Arabic version of the Shoulder Pain and Disability Index **SPADI**. All variables were evaluated before and after the intervention, with three sessions per week for six weeks.
Results: The experimental group had significant improvements in pain intensity (p-value = 0.044), shoulder disability level (p-value= 0.004), and shoulder muscle strength than the control group.
Conclusion: In the treatment of subacromial impingement syndrome, adding core stability training to a traditional therapy program is effective in improving pain, shoulder joint function, and shoulder muscle strength.
Keywords: core stability, subacromial impingement syndrome, exercise.

1. Introduction:

Shoulder pain affects between 7 and 26% of the population on a monthly basis, making it one of the most common musculoskeletal disease presentations (1). Subacromial impingement syndrome (SIS) and rotator cuff tendinitis (RCT) were the most common types of shoulder disorders among outpatients referred to orthopaedic physical therapy clinics at two hospitals in Egypt (in Cairo and Qalubiya). Women were found to be the group most prone to complain about shoulder problems with the right most usually affected side (2).

Subacromial impingement syndrome (SIS) is responsible for 50% of all shoulder problems with a highly variable prognosis and nearly 40% recurrence one year after consultation (3). It leads to disability and absence from work (4). It is possible to explain SIS as the arm is raised, the anatomical structures (rotator cuff, subacromial bursa, and biceps tendon) in the subacromial space are mechanically compressed against the acromion and coracoacromial ligament(5).

SIS is distinguished by acute discomfort in the anterior-lateral shoulder that extends to the deltoid and biceps regions and worsens at night and during abduction, forced internal rotation, and resisted movements (6), together with painful arc of motion, mobility restriction, functional deficiency, and restriction of daily life activities emerge later(7).

The exact reasons which cause SIS are controversial, however, a combination of extrinsic compression and intrinsic degeneration occur(8). Extrinsic compression may occur from the inferior area of the Acromion, the coracoacromial ligament (CAL), and Acromioclavicular (AC) joint (8) while intrinsic degeneration includes all factors that lead to rotator cuff tendon degeneration such as aging, poor vascularity, altered biology, genetic component, overuse, overload and trauma (9,10).

Conservative methods are the most popular available treatment for management of SIS (11) such as immobility, nonsteroidal anti-inflammatory medications (NSAID), corticosteroid injection, physical therapy approaches, manual therapy, elastic

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tape, and acupuncture (12). Physical therapy starts with loosening massage and physical measures as heat or cold application to reduce pain (13) in conjunction to exercise training(pendulum exercise, scaption exercise, wand exercise, strength exercise), electrotherapy such as (transcutaneous electrical nerve stimulation (TENS) , ultrasound, and interferential current) are used to enhance pain, performance, and quality of life especially the physical component (7). Moreover, exercises intended to strengthen core musculature have been incorporated into many training regimens to achieve maximum force output in the both the upper and lower limbs (14).

It has been postulated that core stability plays a crucial role in sports injury and performance (15). The core is essential for offering local strength, stability, and eliminating back pain. It is also recognized key to nearly all kinetic chains of upper and lower extremities (15). The core may be considered as a box, with the abdominal muscle at the front, the back muscles and gluteals in the back, the diaphragm at the roof, and the pelvic and hip girdles musculature at the base functioning as a muscular belt through which energy are formed and delivered to the periphery(16).

Core stability exercises, also known as neuromuscular retraining exercises, are aimed at improving the activation of the locally stabilizer muscles (transversus abdominis and multifidus), globally stabilizer muscles (internal and external obliques), globally mobilizer muscles (rectus abdominus and iliocostalis), and load transfer (i.e.,hip and shoulder girdles) muscles (17).

Core stability has been studied for its influence on shoulder pain, performance, and power of the shoulder girdle musculature in athletes from a variety of sports. Manchado et al. (2017) reported that handball athletes' throwing velocity improved after a rigorous programme of lumbo-pelvic strengthening and training, which improved the stability and the motion kinetics (18). Another study on elite golfers showed that core muscle and non-dominant arm strengthening exercises would develop a successful customized training course for elite or professional golfers (19).

As there is limited evidence on the influence of core stabilization on shoulder pain, function, and strength of shoulder girdle musculature in the non-athletic population, the aim of current study to investigate the impact of core stability exercises on shoulder pain, range of motion, muscle strength, and function in sub acromial impingement in the non-athletic population.

2. Materials and Methods:

Design of study: parallel randomized control trial.

Participants:

The trial included thirty (11 males and 19 females) individuals with SIS who were diagnosed by an orthopedic surgeon and allocated randomly to one of two groups; control group **(C)** who receive conventional physical therapy, and the experimental group (E), who obtains conventional physical therapy as well as core stability training. Ethical Committee of faculty of physical therapy approved the study (P.T.REC/012/003647).

The sample size was estimated for a two-tailed test using (G power programme version 3.1, Heinrich-Heine-University, Düsseldorf, Germany), based on F tests, Type I error () = 0.05, power= 0.80, Pillai V = 0. 5711524, and effect size f2 (V) = 0.3997294 for pain intensity with 2 group's comparison.

The study included subjects who met the following criteria: 1) Age of the patients 25-40 years. 2) Unilateral shoulder pain for at least three months. 3) Rotator cuff tendons tenderness. 4) Positive impingement tests (Hawkins, Neer's test, Empty can test) or a painful arc of movement (60°– 120°). 5) Pain during shoulder (flexion and/or abduction). Individuals who met any of the following criteria were excluded from investigation: 1) A cervical screening check reproduces cervical or shoulder symptoms. 2) Abnormal reflex or positive thoracic outlet tests. 3) Numbness or tingling of upper extremity symptoms. 4) Becoming pregnant. 5) Shoulder fracture or previous shoulder surgery. 6) Acromioclavicular joint separation or dislocation of shoulder joint, full-thickness tear of rotator cuff.

2.1. Evaluative procedures

The research team gave participants detailed information about the study procedure and the safety of assessment and of treatment method and obtained written consent from all participants.

Individuals were randomly allocated to one of two groups using opaque envelope labeled with the name of one of each group (C) or (E). The envelopes were chosen by a colleague who was not involved with the recruitment, treatment, or evaluation of individuals. Group assignment was completed following baseline assessment but prior to the first treatment session.

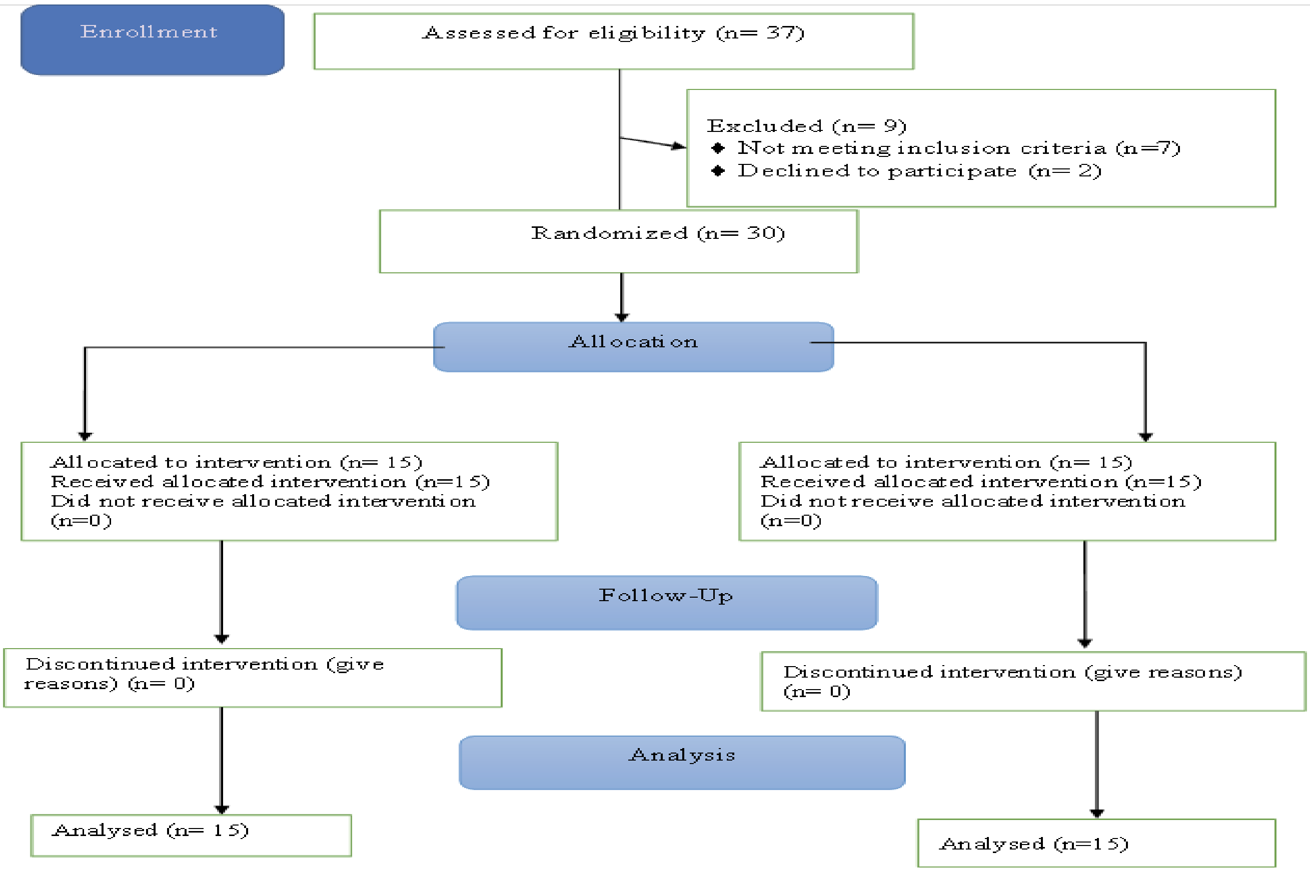

Figure1: flow diagram

Outcome measures:

Patient's characteristics (age, weight, height, and BMI) were obtained. The outcomes were evaluated just before and after the 6 weeks of intervention (20,21) by blind assessor; outcomes included :

Primary outcomes: Pain intensity, and shoulder disability level .

Secondary outcome: Shoulder muscle strength (which included shoulder abductors, external rotators, and internal rotators muscles).

2.1.1. Pain:

Pain severity was assessed through using VAS (visual analogue scale). The patients were instructed to express their pain level using a 10 cm VAS, on a scale of 0 (no discomfort) to 10 (severe pain) (maximum pain). All of the following factors were considered: present pain at rest, discomfort with shoulder movement, greatest pain in the previous week, and least pain in the previous week. The VAS has been shown to be a reliable and valid measure for measuring pain intensity changes. Test-retest reliability is claimed to be between 0.95 and 0.97(22).

2.1.2. Shoulder joint function:

It was evaluated using the Arabic version of the Shoulder Pain and Disability Index (SPADI), which is accurate and reliable for assessing shoulder performance in patients with shoulder problems (23).

The SPADI is divided into two subscales: pain and disability. The subscales consist of five items for "pain" and eight items for "disability," which are associated with various shoulder conditions. Each item is responded to by a visual analogue scale ranging from "no pain"/"no difficulty", to "worst imagined suffering "/"so rough required help". The item scores from each segment were averaged to provide independent subscale scores ranging from 0 to 10. Total SPADI score ranges from 0 (best) to 100 (worst) (worst). It is calculated by averaging the two subscale values.

2.1.3. Shoulder muscle strength:

It was assessed by Handheld Dynamometer (Lafayette Manual Muscle Test System (MMT) Model 01163 3700 Sagamore Parkway North. PO Box 5729. Lafayette, IN 47903 USA. Ph: 765-423-1505). HHD is portable, easy to use, highly valid, reliable and contributes valuable data (24).

Subjects were asked to lay supine for abduction, internal and external rotation isometric strength evaluations with the tested shoulder at 90 degrees abduction, 90 degrees elbow flexion, and a neutral wrist position. The examiner provided stability with a belt across the chest to eliminate any assistance from the scapular musculature. The examiner administered a counter force to each individual as they performed an isometric contraction in the desired direction. Each isometric contraction was sustained for approximately 3 seconds, with a 10-second rest time between measurements and a 2-minute resting time between movements. Three trials were carried out, and the average of the three trials was utilized for statistical analysis based on measurement (24).

2.2. Treatment procedures

Each training session for both groups started with 15 minutes of generalized warming up throughout the intervention. At the initial therapy session, the maximal load for all strengthening exercises was assessed and reassessed regularly to make any required changes.

2.2.1. Control group (C)

It underwent (conventional physical therapy) a six-week course of electrotherapy, strengthening exercises, and mobility exercises as follows:

2.2.1.1. Electric hot pack (Electric Heating Pad H17003B Laica, 40 x 32 cm, 220-240V, AC, 50Hz, 60W with a polyester cover) was applied for 15 minutes over the upper trapezius muscle and deltoid muscle,

2.2.1.2. Ultrasound therapy (Gymna Pulson 200 Multifrequency head (1and 3 MHz), 4 cm, acoustic contact control, GymnaUniphy NV Pasweg 6A | B-3740 Bilzen, Belgium) of 1 MHz and an intensity of 1.5 W/cm2 in the continuous mode for 5 minutes applied on the subacromial region.

2.2.1.3. Transcutaneous electrical nerve stimulation (TENS) (Gymna DUO 200 2-channel electrotherapy, 2-pole and 4- pole. Low and medium frequency currents, GymnaUniphy NV Pasweg 6A | B-3740 Bilzen, Belgium) was applied in the conventional mode for 20 minutes with two electrodes (pulse width: 50-250 ms, pulse rate: 90 – 130 Hz) over painful.

2.2.1.4. Exercises: combination of therapeutic exercises as done for 30 minutes each session with 5 minutes rest in between each exercise as:

Pendulum exercises, scaption exercises, range of motion exercises in all direction of shoulder movement, wand exercises, isomeric exercises and resistive exercises of the shoulder girdle. Exercises repetitions started with 1 set and 10 repetitions once a day progressing to 3 sets, 15 repetitions and 3 times per day according to (7,25). The workout regimen was carried out under the direction of a highly skilled physiotherapist (**table 1**).

2.2.2. Experimental Group (E):

Patients received the same interventions as in the control group in addition to core stability exercises (**table 2**). For each exercise, contraction was maintained for 8 sec, repeated 10 times, rest interval of 8 sec between repetitions. Patients were given 3 -min rest in between exercises. The core stability exercises were done at different positions starting from simple and easy levels progressing to more advanced and hard levels as tolerated by the patients.

Statistical analysis:

The normality of data was examined by Shapiro-Wilk test, non-parametric analysis is done for shoulder pain, shoulder joint function, and muscle strength variables as the data non-normally distributed .

Statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL) was used for data analysis conducted by using. Quantitative data for age, weight, height, BMI, shoulder pain, shoulder joint function, and muscle strength variables are expressed as mean and standard deviation. For qualitative gender and shoulder affected side data are expressed as number and percentage. To compare subject's characteristics between both group independent-t test and chi-square were used. Wilcoxon signed ranks test used to compare between pre- and post-treatment within experimental group and control group for dependent variables. Mann-Whitney U test used to compare between experimental group and control group at pre- and post-treatment for all variables. All statistical analyses were significant at level of probability ($P \leq 0.05$).

3.Results:

3.1. Subject characteristics:

A total of 30 patients (11 males and 19 females) were allocated randomly into two groups. The patient's demographic data (**Table 3**) showed that no significant differences in age (P=0.783), weight (P=0.365), height (P=0.825), BMI (P=0.301), gender (P=0.705), and affected side (P=0.705) between experimental group and control group.

3.2. Within group comparison:

Time effect for shoulder pain, shoulder joint function, and muscle strength variables within each group (**Table 4**) showed that there were significantly decreased in shoulder pain and increased in shoulder joint function at post-treatment compared to pre-treatment within experimental group (P=0.001 and P=0.001, respectively) and control group (P=0.001 and P=0.001, respectively).

Time effect had significantly increased in shoulder abductors at post-treatment compared to pre-treatment within experimental group (P=0.001) and control group (P=0.001) and shoulder flexors (P=0.001) and control (P=0.001 .(

Shoulder external rotators at post-treatment significantly ($P<0.05$) higher than pre-treatment within experimental group (P=0.001) and control group (P=0.001). Shoulder internal rotators significantly increased at post-treatment versus pre-treatment within core stability exercises group (P=0.001) and control group (P=0.001).

Table (1). Details of the therapeutic exercises:

Type of exercise	Description
Pendulum	Assume standing position then use a table or chair for support, gently sway the body weight from left to right or in a circular manner to move the arm in a spiral manner. Reverse the action five times in each direction, three times per day for five minutes, and progressively increase to five times per day in 5-to-10-minute sessions.
Scaption	Standing then elevates the arm (full range of motion) with (thumbs up) in the scapular plane (30°).
Range of motion	Standing then moves the shoulder in all directions of motion for shoulder joint.
Wand exercises	**Flexion:** Standing with both hands held on a stick (palms down), raise the arms above the head with straight elbows, then return and repeat 10 times.
	Extension: standing holding a stick behind the back then move the stick away from the back, return and repeat 10 times.
	External rotation: Lying supine with both hands on a stick, palms up, arms on the floor, elbows at the sides, and bent 90°. Push the affected arm out away from the body with the affected arm's elbow at the side, return, and repeat 10 times.
	Internal rotation: standing with a stick behind the back, one hand behind the head on the non-affected side and the other behind the back at the waistline on the affected side. Bend your elbows and move the stick upwards and downwards on your back return and repeat 10 times.
	Shoulder abduction and adduction: Standing, palms down, grasp a stick against the front thighs. Push the afflicted arm out to the side and as high as possible, then return and repeat 10 times.
Isometric exercises:	**Flexion:** Stand in front of a wall, make a fist with the hand and position a cushion between the fist and the wall, then press the fist to the wall for 5 seconds, then relax, and repeat 10 times.
	Extension: patient stand with his back to a wall and a cushion in between wall and the back of his elbow then press his elbow back against the wall for 5 seconds, relax, and repeat 10 times.
	Abduction: Place a cushion between the wall and the outside of the elbow from standing position, then press the elbow towards the wall, hold for 5 seconds, then relax, and repeat 10 times.
	Adduction: patient place a cushion between the arm and the trunk, squeeze the cushion into the torso with the arm, holding for 5 seconds, then relax, and repeat 10 times.
	External rotation: patient stand with one side facing the wall, elevate the arm so that the upper arm is level with the ground and the elbow is bent 90 °, place a cushion between the wall and the elbow, and then press the elbow towards the wall, holding for 5 seconds, then relax, and repeat 10 times.
	Internal rotation: patients stand at a corner of a wall, arm elevated to shoulder height, elbow flexed so the forearm is level to the wall, and a cushion positioned between the forearm and the wall, squeeze the cushion against the wall for 5 seconds, relax, and repeat 10 times.
Strength exercises:	by using an elastic band in all directions (after pain subsides) starting with 1 set and 10 repetitions once a day, advancing to 3 sets, 15 repetitions, and 3 times each day. The elastic band's resistance increased in accordance with the participant's tolerability.

Table 2: core stability exercises

Position	Exercise description
Supine hook lying position	**Abdominal drawing-in** patient was pulled the abdomen deeply to the lumber region, hold for 8 sec then relax and repeat 10 times with 8-sec rest.
	Abdominal drawing-in with alternate shoulder mobility: flex the shoulders alternately (elbows extended and forearms pronated) and return to starting position 5 times with keeping the abdominal contractions and advanced up to 10 sets of 5 repetitions.
	Abdominal drawing-in with alternate lower - limb mobility: patient flex the hip joint with knee bent and return to the initial position alternately 5 times with sustaining abdominal tension and advanced to 10 sets of 5 repetitions.
	Abdominal drawing-in with alternate upper and lower limbs mobility: flex the contralateral upper and lower limbs and return to initial position alternately for 5 times with sustaining the abdominal tension in the supine position, advanced to 10 sets of 5 repetitions.
	Curl-up exercises: Place both hands on the thighs, lift both shoulders and upper torso of the floor till their fingers touch the knees, hold for 8 seconds, then return to where they started, and advanced up to 10 sets of 5 repetitions.
Supine lying position	Raise one leg upward, with the knee extended, and the other leg held out horizontally off the floor, hold for 8 seconds, then return to initial position and advanced up to 10 sets of 5 repetitions.
Quadruped position	Pull the abdominals inward toward the spine, reach with one arm forward and stretch the contralateral leg backward while maintaining the back, shoulders, and pelvis in place, stay for 8 seconds, then return to the initial position, continue on the other side, and advanced up to 10 sets of 5 repetitions.
Prone lying position	Raise the contralateral upper and lower limbs to the horizontal plane alternately for 5 times with sustaining an abdominal tension, then return to the initial position and advanced up to 10 sets of 5 repetitions.
Prone -bridge	Keep a straight position of the body anchored by the elbows and toes, tighten the abdominal muscles, keep the back neutral, stay for 30 seconds, then relax and continue up to 10 times with a 30-second break in between.
Side -bridge	Lie on one side with their legs stretched and stacked from hips to feet, and the elbow on that side just underneath the shoulders. Keeping the head in line with the spine and the upper hand aligned with the top side of the body, pull the navel into the spine about 30 seconds, relax, and continue 10 times with a 30-second break in between.

3.3. Between groups comparison:

Pairwise comparison tests (group effect) for shoulder pain, shoulder joint function, and muscle strength variables between both groups (Table 4) there were significant differences between experimental group and control group at post-treatment for shoulder pain (P=0.044), shoulder joint function (P=0.004), shoulder abductors (P=0.000), shoulder flexors (P=0.001), shoulder external rotators (P=0.000), and shoulder internal rotators (P=0.000).

4.Discussion:

The goal of this study was to look at how core stability exercises affected shoulder pain, disability level, and muscular strength in non-athletic individuals with SIS. The statistical analysis showed that all end measures improved within each group, with the core stability exercises group beating the typical physical therapy group in shoulder pain, shoulder joint function, and muscular strength.

Table 3. Comparison of general characteristics of subjects between both groups

Items	Groups		*P*-value
	Experimental group (n=15)	Control group (n=15)	
Age (year)	31.93 ±4.30	31.46 ±4.88	0.783
Weight (kg)	77.33 ±11.55	81.46 ±13.00	0.365
Height (cm)	170.47 ±6.32	170.00 ±5.04	0.825
BMI (kg/m^2)	26.61 ±3.97	28.08 ±3.66	0.301
Gender (Males: Females)	6 (40.00%): 9 (60.00%)	5 (33.30%): 10 (66.70%)	0.705
Shoulder side (Right: Left)	9 (60.00%): 6 (40.00%)	10 (33.70%): 5 (33.30%)	0.705
P-value: probability value		**NS: non-significant**	

The improvement in shoulder muscular strength in this study was validated by Gurudut et al, who discovered a substantial effect on shoulder muscle strength following 5 weeks of core strengthening regimen in young obese individuals (26). Similarly, Mısırlıoğlu et al. (2018) discovered a substantial favourable effect on shoulder maximum voluntary isometric contraction following a 6-week core stability training program (21).

In contrary, Ayhan et al. (2014) investigated the advantages of incorporating core stability training to typical rehabilitation in patients with arm injuries for 6 weeks in research (27), Although functional measures such as pain, ROM, DASH score, and fatige severity did not improve, the results of this research demonstrated a reduction in the degree of compensation and an optimization of movement pattern by increasing proximal stability.

On the other hand, the impact of core stabilisation on sport and athletic performance has been studied extensively. For example, Weston et al. reported a significant effect of a 12-week isolated core training on 50-m front-crawl swim performance, shoulder extension (maximal voluntary contraction MVC) in the sagittal plane, and prone bridge performance (28). The gain in 50-m front-crawl swim performance, shoulder extention (maximal voluntary contraction MVC) in this research is in agreement with our results in shoulder function and shoulder muscular strength. The core stability programme in this study is similar to our intervention, although a small sample size was included and only done on young swimmers.

Also, Manchado et al. (2017) found that after 10 weeks of training sessions, the throw speed of 30 male handball players increased (18). Throughout this trial, enhanced lumbo-pelvic region muscular strength leads to increased shoulder muscle strength, which improves throwing speed and supports our findings in shoulder muscle strength despite the differing workout regimen.

As in the previous study, the maximum throwing velocity of 24 female handball players enhanced following 6 weeks of a sling exercise training (SET)-based core training program (20). This study employs sling exercise training SET, a low-volume, high-intensity core-training program with precise planes of motion and axes of rotation that created a 3D instability environment, resulting in increased activation of the muscles involved in shoulder and core stabilization. This study's conclusions reflect our findings in terms of shoulder muscle strength, although with a different core training approach.

The core stability exercises were designed to maintain optimal musculare balance around the lumpo-pelvic hip complex, forming a solid cylinder resisting body perturbations and giving a solid basis for precise extremity motions. As a result, good core function results in powerful, optimal, and functional movement of the extremities.

This research has certain limitations: Initially, this investigation was conducted on a small group of people aged 25 to 40 years (neer stage 2 categorization). As a result, more research is needed to determine if core stability activities improve shoulder muscular strength in the elderly and adolescent populations. Second, no follow-up (6 weeks) is insufficient to achieve core stability, particularly in the non-athletic group. Lastly, while this study looked at the effect of core stability training paired with traditional physical therapy on subacromial impingement, future research might look at the benefit of core stability training alone without traditional treatment.

5.Conclusion

Core stability training coupled with standard physical therapy is beneficial in reducing pain, shoulder joint function, and shoulder muscular strength in SIS treatment.

Conflict of interest: None

Fund: Self-funded

Table 4: Comparison for shoulder pain, shoulder joint function, and muscle strength pre-post treatment.

	Items	Groups (Mean ±SD) Experimental group (n=15)	Control group (n=15)	MD	*P*-value
VAS	**Pre**	6 ±2	6 ±2	0.3	0.672
	Post	3 ±2	3 ±2	0.4	0.044*
	(MD)	3	3		
	%	55%	50 %		
	***P*-value**	0.001*	0.001*		
Function	**Pre**	70 ±10	73 ±6	3	0.419
	Post	83 ±8	74 ±10	9	0.004*
	(MD)	13	1		
	%	19%	1%		
	***P*-value**	0.001*	0.001*		
abductors	**Pre**	395±60	344 ±37	51	0.056
	Post	633±153	396±47	237	0.000*
	(MD)	238	53		
	%	60%	15%		
	***P*-value**	0.001*	0.001*		
flexors	**Pre**	398±82	378±48	20	0.82
	Post	616±167	423±61	194	0.001*
	(MD)	218	44.		
	%	55%	12%		
	***P*-value**	0.001*	0.001*		
external rotators	**Pre**	448±82	299±20	148	0.000
	Post	650±139	343±32	307	0.000*
	(MD)	203	44		
	%	45%	15%		
	***P*-value**	0.001*	0.001*		
internal rotators	**Pre**	414±64	305±21	110	0.000
	Post	648±109	350±34	298	0.000*
	(MD)	232.94	45.07		
	%	56%	15%		
	***P*-value**	0.001*	0.001*		

MD: mean difference **P-value: probability value**
*** Significant (P<0.05)** **%: percent of improvement**

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