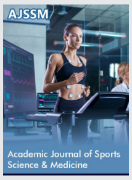

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Research Article

Effectiveness of Exercise Therapy as A Conservative for Treatment for Scapulohumeral Dyskinesia in Overhead Athletes. A Systematic Review

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Abstract

Introduction: Scapulohumeral dyskinesia (SHD) is a musculoskeletal disorder that causes loss of coordination and movement of complex shoulder kinematics. There is no doubt that exercise is the treatment with the highest recommendation and level of evidence. However, the superiority of one therapeutic exercise modality over another is uncertain.

Aim: The purpose of this systematic review is to identify, analyze, and summarize the existing literature on the clinical effectiveness of exercise therapy interventions as conservative treatments for SHD-related shoulder injuries in overhead athletes.

Materials and methods: A systematic review was performed following the PRISMA statement. The search was conducted in MEDLINE (Pubmed), CENTRAL, PEDro and SportDiscus databases for three months using MeSH and free terms related to the topic and combined with booleans "AND"/"OR"/"NOT". PEDro Scale and RoB 2 tool were used to assess the methodological quality and risk of bias, respectively.

Results: A total of 7 studies (n=346) were finally included. Therapeutic exercise alone or in combination with alternative therapies such as manual therapy has a greater effect in the treatment and recovery of SHD.

Conclusions: Exercise therapy is effective as a monotherapy for the treatment of SHD and related shoulder injuries. Additionally, when combined with alternative therapies such as manual therapy, they may provide more progressive and effective benefits in increasing and reorganizing scapular muscle activation, restoring normal scapular kinematics, and thereby improving stability of the complex shoulder joint.

Keywords: Scapular Dyskinesia; Muscle Dyskinesia; Upper Trapezius; Middle Trapezius; Lower Trapezius; Serratus Anterior; Shoulder Instability; Shoulder Injury

Introduction

Scapulohumeral dyskinesia (SHD) is a musculoskeletal disorder of the scapula. It is caused by static or dynamic dysfunction of the glenohumeral (GH) and scapulothoracic (ST) joints, resulting in loss of coordination and movement of the complex kinematics of the shoulder [1]. From a biomechanical perspective, the shoulder joint is a lax joint group with a full range of motion of the joint, so its stability depends largely on passive (skeletal integrity and ligaments) and active (muscle activity) factors. The rotator cuff and scapular muscle complex are responsible for energy distribution and force transfer during GH and ST movements [2]. The cardinal feature of this pathology is muscular changes in the sequence or degree of activation of the scapular muscles and rotator cuff. This muscle change causes instability in the GH and ST joints, so the joint integrity of the shoulder may be compromised. People with shoulder disease (GH instability, subacromial impingement syndrome, labral tears, etc.) often experience changes in the scapula [1].

Although they share many clinical manifestations, from the perspective of the biomechanical relationship between the scapula and the chest, SHD can be divided into four types: posterior inferomedial angle separation of the scapula (type I), posterior inferomedial angle separation of the scapula (type I), posterior separation of the inferior angle of the scapula (type I), separation of the entire medial edge of the scapula, posterior separation of the ribcage (type II), elevation of the upper edge of the scapula and/or forward displacement of the scapula from the back of the ribcage (type III), and symmetry of the scapula on both sides Scapula (type IV) [3]. Although static or dynamic changes in the scapula are physical consequences, SHD may be affected by factors that are neither passive (bone joints) nor active (muscles), such as neurological problems. Artifacts occur in nerves that innervate the scapular muscles, such as the long thoracic nerve (which innervates the serratus anterior) or spinal nerves (which innervate the upper trapezius and sternocleidomastoid muscles) that can lead to muscle inactivity due to lack of nerve conduction [2].

Indeed, EMG studies can identify hyperactivation and hypotonia of the upper trapezius (TS), pectoralis minor (PM), scapula (LS), and teres major (MR) muscles in these patients. Activity of the middle/lower trapezius (TM/TI), serratus anterior (SA), and rhomboids major or minor (RoM/Rm) can cause muscle enlargement due to lack of nerve conduction, resulting in postural imbalance [3]. The shoulder joint plays an important role in the normal function of the upper limb, and pathologies of this joint are often very common during daily activities, with a lifetime risk of 40% to 60%. Some groups are most vulnerable to injury, such as office workers or athletes we focus on, who perform high-speed repetitive movements or raise their arms above their heads to provide resistance (volleyball, swimming, tennis, handball, etc.) [4].

SHD has been identified in both symptomatic and asymptomatic athletes and is associated with pathologies such as shoulder instability and subacromial impingement syndrome. There are factors that can help us identify and prevent an increased risk of shoulder injury early. These are glenohumeral internal rotation deficit (GDR), rotator cuff strength (especially ER), and scapular dyskinesia. It's worth noting that these athletes typically have good mobility in their shoulders (called the "overhead") but require a lot of stability to perform the throwing motion. This is known as the "Thrower's Paradox" [4]. From a therapeutic perspective, SHD can be treated with a variety of invasive and conservative treatments aimed at relieving shoulder pain, improving upper extremity function, and improving the patient's quality of life. Regardless of the treatment modality, it is clear that exercise is the most highly recommended and evidence-based treatment for changes in shoulder motion because it is effective in restoring normal scapular kinematics [5]. However, the superiority of one therapeutic exercise modality over another is uncertain [2].

Apart from the evident clinical relevance of the present information, there exists a dearth of recent studies that systematically evaluate and quantify the therapeutic impacts of diverse exercise application modalities for Subacromial Impingement Syndrome (SHD) across various follow-up durations. This underscores the need for comprehensive research to gauge their potential effectiveness. The purpose of this systematic review is to identify, analyze, and summarize the existing literature on the clinical effectiveness of exercise therapy interventions as conservative treatments for SHD-related shoulder injuries in overhead athletes.

Materials and Methods

Study Design

This systematic review study was conducted using an established protocol and divided into four phases according to the criteria of the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-analyses). A systematic search of articles was conducted independently using the same method in the following databases: MEDLINE (PubMed)(18/07/2023 to 29/07/2023), CENTRAL (24/07/2023 to 29/07/2023), PEDro (07/24/2023), Web of Science (WOS) (02/09/2023) and SportDiscuss (09/10/2023 to 09/11/2023) with a combination of the different Mesh terms "exercise", "exercise therapy", "rehabilitation", "athlete*", "shoulder", "shoulder pain", "shoulder joint", "scapula" and free terms "scapular dyskinesia" and "scapular winging" combined with the boolean operators "AND"/"OR"/"NOT". Two independent researchers (ARO and SMP) screened and assessed the titles and abstracts of all retrieved articles and then assessed full-text publications to determine eligibility. This procedure was performed according to study inclusion and exclusion criteria by each investigator involved in this part of the study, and discrepancies were resolved by a third author (IMP). We checked the reference list of each article to identify additional original articles (Table 1).

Table 1: Search strategy.

Date	Database	Search terms	Search equations
18-07-23	MEDLINE (PubMed)	MeSH: "exercise", "rehabilitation", "person", "athlete" Free terms: "scapular dyskinesis", "winged scapula", "rehab"	("Scapular dyskinesis" OR "winged scapula") AND (Rehab OR Rehabilitation OR Exercise*) AND (Person* OR athlete*)
20-07-23	MEDLINE (PubMed)	MeSH: "exercise", "exercise therapy", "rehabilitation", "person", "athlete", "shoulder" Free terms: "scapular dyskinesis", "winged scapula", "rehab".	("Scapular dyskinesis" OR "winged scapula" OR "Shoulder") AND (Rehab OR Rehabilitation OR Exercise* OR "Exercise Therapy") AND (Person* OR athlete*)
24-07-23	MEDLINE (PubMed)	MeSH: "exercise", "rehabilitation", "person", "athlete", "shoulder", "shoulder joint", "shoulder pain", "scapula". Free terms: "scapular dyskinesis", "winged scapula", "rehab", "injury prevention".	("Scapular dyskinesis" OR "winged scapula" OR "Shoulder" OR "Shoulder pain" OR "Shoulder joint" OR "Scapula") AND (Rehab OR Rehabilitation OR Exercise* OR "Injury prevention") AND (Person* OR athlete*)
29-07-23	MEDLINE (PubMed)	MeSH: "exercise", "rehabilitation", "person", "athlete", "scapula" Free terms: "scapular dyskinesis", "winged scapula", "rehab", "injury prevention"	("Scapular dyskinesis" OR "winged scapula" OR "Scapula") AND (Rehab OR Rehabilitation OR Exercise* OR "Injury prevention") AND (Person* OR athlete*)
24-07-23	CENTRAL (Cochrane)	MeSH: "exercise", "rehabilitation", "person", "athlete" Free terms: "scapular dyskinesis", "winged scapula", "rehab"	("Scapular dyskinesis" OR "winged scapula") AND (Rehab OR Rehabilitation OR Exercise*) AND (Person* OR athlete*)
29-07-23	CENTRAL (Cochrane)	MeSH: "exercise", "exercise therapy", "rehabilitation", "person", "athlete", "shoulder" Free terms: "scapular dyskinesis", "winged scapula", "rehab".	("Scapular dyskinesis" OR "winged scapula" OR "Shoulder") AND (Rehab OR Rehabilitation OR Exercise* OR "Exercise Therapy") AND (Person* OR athlete*)
29-07-23	Web of Science (WOS)	MeSH: "exercise", "rehabilitation", "person", "athlete" Free terms: "scapular dyskinesis", "winged scapula", "rehab"	("Scapular dyskinesis" OR "winged scapula" OR "Shoulder") AND (Rehab OR Rehabilitation OR Exercise* OR "Exercise Therapy") AND (Person* OR athlete*)
24-07-23	PEDro	MeSH: "shoulder", "athlete", "exercise" Free terms: "scapular dyskinesis", "rehab"	Shoulder* Scapular Dyskinesis exercise* Athlete* Rehab*
10-09-23	Sportdiscus	MeSH: "exercise", "rehabilitation", "person", "athlete", "scapula" Free terms: "scapular dyskinesis", "winged scapula", "rehab", "injury prevention"	("Scapular dyskinesis" OR "winged scapula" OR "Shoulder") AND (Rehab OR Rehabilitation OR Exercise* OR "Exercise Therapy") AND (Person* OR athlete*)
11-09-23	Sportdiscus	Free terms: "Scapular stabilization exercises"	"Scapular stabilization exercises"

Eligibility criteria

Type of Study:

- Randomized and non-randomized experimental studies and cross-sectional or longitudinal observational studies.
- Published in English or Spanish.
- Published full text between 2013 and 2023.

Type of participants:

- Athletes, regardless of age, gender and sport level, suffer from SHD (type I/II/III) and/or postural changes (upper cruciate ligament syndrome, round shoulders, etc.)
- Those who apply a physical exercise program or a specific exercise sample as a conservative treatment for injury recovery rather than prevention, regardless of direction: structural, metabolic or neurological and/or with other techniques (manual therapy, PRP, stretching, etc.)
- The motor function of the upper limbs and the development of specific symptoms of various pathologies were specifically evaluated before and after surgery with variables such as: voluntary maximum strength (dynamometer), range of motion (ROM), muscle imbalance (activation ratio), perceived pain scale (VAS scale or similar), etc.

Data extraction process

ARO researchers are responsible for independently selecting the articles, documenting the results obtained, and using a structured protocol based on a standardized extraction form that contains information on study characteristics (author, year of publication, title, aims, type of study, collection and language) and participant characteristics (study population, number of subjects), interventions, comparison of outcomes and conclusions. Preparatory work included the Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0, which was used to develop each section. After completing the screening process, both parties simultaneously agreed to exclude duplicate studies and studies that were not relevant to the research question after reading the abstract or full text. Finally, in the event of disagreement regarding the inclusion or exclusion of articles, a protocol was developed with a VCS research expert who was not involved in the study serving as the adjudicator.

Methodological Quality Assessment

SMP and CRM researchers independently assessed methodological quality using the PEDro scale. This analysis tool was reported to be a valid and reliable tool for measuring the methodological quality of interventional clinical trials. It consists of 11 elements, each with a value of 1. This allows us to assess whether a randomized clinical trial has sufficient internal validity (criteria 2-9) and sufficient statistical information to make its results interpretable (criteria 10-11). These parameters are independently assessed by the IMP and any disagreements are resolved until consensus is reached.

Risk of bias assessment

Risk of bias were independently performed by ARO using the Cochrane Risk of Bias Tool for Randomized Trials (RoB 2.0). The tool evaluates the methods researchers use in clinical trial design and individually rates the presence of the following biases: (1) randomization process, (2) deviations from the intended interventions, (3) missing outcome data, (4) measurement of the outcome and (5) selection of the reported result. Interpretation of the scores obtained considers the fact that a low risk of bias means that the bias committed is unlikely to significantly alter the results, whereas a high risk of bias indicates lower confidence in the results receive. Any disagreement of the authors was resolved by discussion, and in case of conflicting scores, the third reviewer VCS resolved to make the decision.

Results

Selection of studies

A total of 208 studies were identified and analyzed through agreed searches in the detailed databases MEDLINE (PubMed) (n = 148), Web of Science (WOS) (n = 21), PEDro (n = 1), and the CENTRAL (Cochrane Library) (n = 14) and Sport Discus (n = 24). After removing duplicates (n = 38) and analyzing the titles and abstracts of the remaining articles (n = 110), 60 full-text articles were potentially relevant studies based on the search strategy. Finally, 48 of these manuscripts were excluded because these studies did not meet our eligibility criteria because they had different study designs (n = 48), were published in different languages (n = 3) and conducted different interventions (n = 90) and text is not available (n = 2). Therefore, seven studies were ultimately selected for qualitative synthesis in this review (Figure 1).

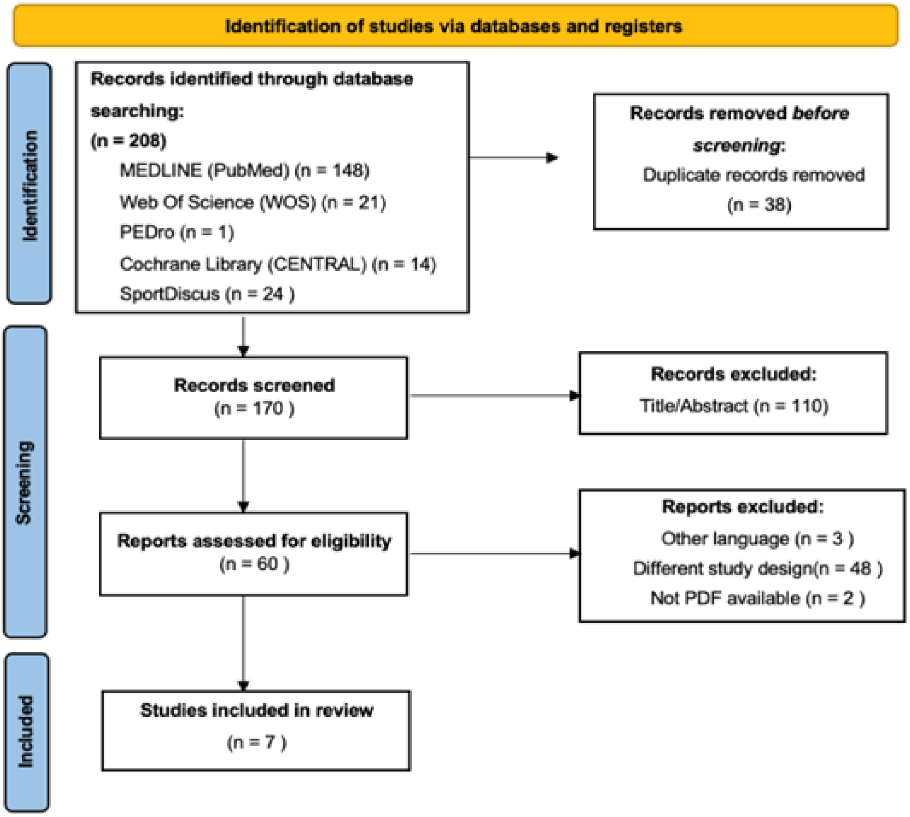


Figure 1: Flowchart (PRISMA).

Characteristics of the included studies

We included a total of 7 studies (n=346) 3 single-blind parallel-group controlled trials, 1 single-blind parallel-group randomized controlled trial, 1 randomized controlled trial with a two-arm parallel repeated measures design, 1 cross-sectional observational study, and 1 case series. All included studies looked at "overhead" athletes diagnosed with some type of scapulohumeral dyskinesia and/or associated shoulder injury, regardless of sport level (recreational, amateur, professional, etc.). Most studies involve physical training interventions based on supervised rehabilitation programmes. Strengthening exercises, proprioception, and stretching exercises are performed with the primary goal of improving static and dynamic scapulae, thereby improving shoulder stability. Most studies divide intervention programs into three phases in which subjects are gradually able to gain joint mobility, strength, and stability. Variables related to time before and after intervention were tracked inconsistently, ranging from 30 minutes to 8 weeks. The seven included studies were conducted in the following countries: Brazil, China, United States, and Brazil. United States, Spain and India (Table 2).

Table 2: Study characteristics.

Authors, year	Study design	Participants	Intervention	Comparation	Outcomes	Conclusion
Luo et al. (2023)	RCT (Single-blinded parallel group)	n= 41 (1) Overhead athletes aged 20 to 40 (2) Type I or II scapular dyskinesis (3) Positive scapula assist test result Inclusion Criteria: (1) Participated in overhead sports for over 4 hours weekly (2) Experienced shoulder pain for more than 2 weeks, localized at the anterior or lateral aspect (3) Confirmed SIS (Subacromial Impingement Syndrome) by at least three of the following: (a) Positive Neer test (b) Positive Hawkins sign (c) Positive empty can test (d) Positive resisted external rotation test (e) Painful arc during arm elevation (f) Tenderness of the rotator cuff tendons	IG: Exercise Group (1) Arm Elevation to 90° in a Sitting Position (2) Shoulder Flexion to 90° in a Sidelying Position (3) Shoulder External Rotation in a Sidelying Position Dosage: 10 reps 3-second concentric and 3-second eccentric phase, guided by a metronome and pain-free movement. Exercise Goals: - Activate the lower trapezius and serratus anterior - Maintain low ratios of UT/LT and UT/SA Supervision: - All training sessions supervised by a licensed physical therapist - The therapist has 2 years of experience in overseeing the exercise program for both groups.	CG: Exercise Strengthening Exercises with Dumbbell	MEPs Post-Training Lower Trapezius ↑ ($F = 10.058$, $P = 0.004$, $\eta 2p = 0.264$) ↑ ($F = 5.242$, $P = 0.030$, $\eta 2p = 0.158$) AMT and CSP Lower Trapezius No significant effects ($F = 0.028–1.761$, $P = 0.195–0.870$, $\eta 2p = 0.002–0.059$) Serratus Anterior No significant effects ($F = 0.028–1.761$, $P = 0.195–0.870$, $\eta 2p = 0.002–0.059$) Scapular Kinematics: Change Post-Training Scapular Upward Rotation ↑ ($F = 4.972$, $P = 0.032$, $\eta 2p = 0.113$) Internal Rotation No significant effects ($F = 0.074–2.201$, $P = 0.146–0.786$, $\eta 2p = 0.002–0.053$) Posterior Tilt No significant effects ($F = 0.074–2.201$, $P = 0.146–0.786$, $\eta 2p = 0.002–0.053$) Scapular Muscle Activation: Change Post-Training Lower Trapezius ↑ ($F = 45.174$, $P < 0.001$, $\eta 2p = 0.537$) Serratus Anterior ↑ ($F = 18.815$, $P < 0.001$, $\eta 2p = 0.325$)	Scapula-focused exercises, whether accompanied by biofeedback and cues or not, demonstrated enhanced scapular control and increased corticospinal excitability. The incorporation of biofeedback and cues specifically targeting scapular control in exercises led to heightened activation of the lower trapezius. Consequently, the inclusion of feedback and cues is advised for optimizing scapula-focused training.

Sharma et al. (2022)	RCT (Single-blinded parallel group)	n = 10 (1) University-level athletes Inclusion Criteria: (1) Age: 17-35 years (2) Male overhead athletes engaged in competitive sports (volleyball, tennis, baseball, cricket, swimming, badminton, basketball) for at least 6 hours a week (3) Duration of shoulder impingement for at least 1 month (4) Pain rating on the visual analogue scale (VAS) of less than or equal to 7/10 (5) Willing to commit to an 8-week supervised physiotherapy program (6) Athletes recruited on fulfilling a minimum of 2 out of 5 diagnostic criteria for Shoulder Impingement Syndrome (SIS)	IG: Exercise group 8-Week Program Range of Motion (ROM) Exercises Inception to Week 4: Dosage: 1 set × 10 reps Dosage: 30 sec hold × 5 times Week 5 to 8: Stretching exercises (7 days a week) Dosage: 1 set × 10 reps Dosage:30 sec hold × 5 times	CG: Exercise + Manual Therapy 8-Week Program Strengthening Exercises: (1) Shoulder Internal Rotation (IR) and External Rotation (ER) in a neutral position (2) Shoulder Extension (3) Scapular Retraction and Protraction (supine) (4) Scapular Retraction with Tuck in Chin Grade I to IV Oscillatory Technique: (1) Thoracic PA glides in prone position (2) Posterior & inferior GH glides in supine position Dosis: 6 sessions	Abduction Angle AHD (Baseline) 0º: ET plus MT 7.74 ± 0.43 / MCE 7.94 ± 0.92 45º: ET plus MT 6.84 ± 0.68 / MCE 7.36 ± 0.78 60ª: ET plus MT 6.29 ± 0.26 / MCE 6.48 ± 0.27 AHD (Post-intervention) 0º: ET plus MT 10.36 ± 0.11 / MCE 8.01 ± 0.90 45º: ET plus MT 10.12 ± 0.10 / MCE 7.46 ± 0.83 60ª: ET plus MT 10.06 ± 0.32 / MCE 6.38 ± 0.83 Mean Difference (Within Group) 2.62 ± 0.18* / 0.07 ± 0.91 3.28 ± 0.40* / 0.10 ± 0.52 3.77 ± 0.30* / 0.10 ± 0.45	The utilization of combined ET (therapeutic exercises) plus MT (manual therapy) demonstrated significant advantages compared to MCE (controlled exercise) alone in enhancing Shoulder Abduction Angle (AHD) at 0°, 45°, and 60°. This intervention proves to be an effective conservative approach for optimizing AHD and is strongly recommended for overhead athletes experiencing Subacromial Impingement Syndrome (SIS
Sharma et al. (2021)	RCT (Single-blinded parallel group)	n = 80 (1) University-level athletes Inclusion Criteria: (1) Age range of 17–35 years (2) Male overhead athletes participating in competitive sports (volleyball, tennis, baseball, cricket, swimming, badminton, basketball) for a minimum of 6 hours per week (3) Experiencing shoulder impingement for at least 1 month (4) Pain rated on the Visual Analogue Scale (VAS) as less than or equal to 7/10 (5) Commitment to an 8-week supervised physiotherapy program (6) Athletes recruited upon meeting a minimum of 2 out of 5 diagnostic criteria for Shoulder Impingement Syndrome (SIS)	IG: Exercise group 8-Week Program Range of Motion (ROM) Exercises Inception to Week 4: Dosage: 1 set × 10 reps Dosage: 30 sec hold × 5 times Week 5 to 8: Stretching exercises (7 days a week) Dosage: 1 set × 10 reps Dosage: 30 sec hold × 5 times	CG: Exercise + Manual Therapy 8-Week Program Stretching Exercises (7 days a week): Inception to Week 4: Dosage: 1 set ×10 reps Dosage: 30 sec hold × 5 times Week 5 to 8 Dosage:: 1 set ×10 reps Dosage: 30 sec hold × 5 times Manual Therapy: (1) Thoracic PA glides in prone position (2) Posterior & inferior GH glides in supine position Dosis: 6 sessions	Baseline Muscle Activation (mv) and Muscle Onset Latency Timings (sec): UT (ET plus MT/ET): Baseline: 117.81 ± 16.23 mv / (− 0.25 ± 0.15) sec 4th Week Post: 116.56 ± 15.33 mv / (− 0.20 ± 0.01) sec 8th Week Post Intervention: 86.59 ± 16.3* mv* / (0.05 ± 0.19)* sec MT (ET plus MT/ET): Baseline: 25.78 ± 5.04 mv / (0.12 ± 0.08) sec 4th Week Post: 26.23 ± 4.96 mv / (− 0.13 ± 0.06) sec 8th Week Post Intervention: 45.50 ± 5.97* mv* / (0.10 ± 4.46)* sec LT (ET plus MT/ET): Baseline: 45.34 ± 13.8 mv / (− 0.34 ± 0.14) sec 4th Week Post: 43.02 ± 13.25 mv / (− 0.31 ± 0.14) sec 8th Week Post Intervention: 79.80 ± 16.32* mv* / (− 0.36 ± 0.10)* sec SA (ET plus MT/ET): Baseline: 30.53 ± 2.73 / (− 0.55 ± 0.20) sec 4th Week Post: 30.14 ± 2.80 / (− 0.53 ± 0.19) sec 8th Week Post Intervention: 40.41 ± 3.56* / (− 0.59 ± 0.18)* sec Post Intervention 8th Week: UT (ET plus MT/ET): 114.21 ± 12.78 mv* / (− 0.21 ± 0.03) sec 112.71 ± 15.46 mv* / (− 0.21 ± 0.15) sec MT (ET plus MT/ET): 27.72 ± 6.78 mv* / (0.12 ± 0.08) sec 28.31 ± 5.87 mv* LT (ET plus MT/ET): 43.72 ± 13.01 sec 43.60 ± 12.10 sec SA (ET plus MT/ET): 30.18* ± 2.67 29.97 ± 3.65 SPADI-H (ET plus MT/ET): Baseline: 58.97 ± 11.91 - 57.00 ± 8.51 4th Week Post: 50.21 ± 10.32* - 56.01 ± 9.36* 8th Week Post Intervention: 41.20 ± 9.77* - 54.58 ± 7.64*	Over the course of 8 weeks, the combined Exercise Therapy (ET) plus Manual Therapy (MT) program exhibited superior efficacy compared to the ET-alone program. Notable enhancements were observed in muscle activity, SPADI (Shoulder Pain and Disability Index) scores, and the optimal sequencing of muscle onset latency timing. This comprehensive approach proved to be more effective in addressing and improving multiple aspects, underscoring its superiority in promoting overall shoulder health and function.

Sharma et al. (2021) b	RCT (Two-arm parallel group)	n=80 (1) University-level athletes Inclusion Criteria: (1) Age: 17–35 years (2) Male overhead athletes playing competitive sports (volleyball, tennis, baseball, cricket, swimming, badminton, basketball) for at least 6 hours a week (3) Duration of shoulder impingement for at least 1 month (4) Pain rating on Visual Analogue Scale (VAS) of less than or equal to 7/10 (5) Willing to commit to an 8-week supervised physiotherapy program (6) Athletes recruited on fulfilling a minimum of 2 out of 5 diagnostic criteria for Shoulder Impingement Syndrome (SIS)	IG: Exercise + Manual Therapy 8-Week Program Strengthening Exercises: (1) Shoulder Internal Rotation (IR) and External Rotation (ER) in a neutral position (2) Shoulder Extension (3) Scapular Retraction and Protraction (supine) (4) Scapular Retraction with Tuck in Chin Stretching Exercises (7 days a week): Inception to Week 4: Dosage: 1 set ×10 reps Dosage: 30 sec hold × 5 times Week 5 to 8 Dosage:1 set ×10 reps Dosage: 30 sec hold × 5 times Manual Therapy: (1) Thoracic PA glides in prone position (2) Posterior & inferior GH glides in supine position Dosis: 6 sessions during 4 weeks	CG: Exercise group 8-Week Program Strengthening Exercises: (1) Shoulder Internal Rotation (IR) and External Rotation (ER) in a neutral position (2) Shoulder Extension (3) Scapular Retraction and Protraction (supine) (4) Scapular Retraction with Tuck in Chin Stretching Exercises (7 days a week): Inception to Week 4: Dosage:1 set ×10 reps Dosage:: 30 sec hold × 5 times Week 5 to 8 Dosage:1 set ×10 reps Dosage: 30 sec hold × 5 times	Isometric Strength of Scapular Muscles (N) in 4th and 8th Week: UT (PRE + MT / MCE): 4th Week: (23:35 ± 21:21* - 0.82 ± 1.27*) 8th Week: (36:26 ± 26:97 - 2:02 ± 1:84*) MT (PRE + MT / MCE): 4th Week: (−20:57 ± 14:66* - −0:34 ± 1:65*) 8th Week: (−40:78 ± 13:29* - −1:95 ± 2:02*) LT (PRE + MT / MCE): 4th Week: (−25:02 ± 23:34* - −0:94 ± 1:43*) 8th Week: (−45:39 ± 29:71* - −1:38 ± 3:10*) SA (PRE + MT / MCE): 4th Week: (−14:02 ± 7:96* – (−0:54 ± 0:54*)) 8th Week: (−49:27 ± 9:29 – (−2:52 ± 1:47)) Supr (PRE + MT / MCE): 4th Week: (−31:77 ± 11:96* – (−0:88 ± 1:47**)) 8th Week: (−55.32± 14:10* – (−0:61 ± 5.07**)) A.D (PRE + MT / MCE): 4th Week: (21:03 ± 7:96* - 1:33 ± 1:02*) 8th Week: (47:03 ± 10:58* - 2:24 ± 1:43*) LD (PRE + MT / MCE): 4th Week: ((-14.27 ± 9.51*) - (-0.38) ± 0.91*)) 8th Week: ((-44:57 ± 7.59* - 1.53 ± 1.26*)	PRE plus MT intervention demonstrates superior effectiveness and clinical superiority when compared to the MCE intervention in inducing improvements in the isometric strength of overhead athletes with Shoulder Impingement Syndrome (SIS).

Gaballah et al. (2017)	NRCT (Quasi-experimental study)	n = 12 Inclusion criteria: (1) Overhead Athletes (2) Over the age of 18 years old (3) Suffering from shpulder pain caused by SIS Exclusion criteria: (1) Recurrent dislocated shoulder (2) history of injury in the same joint.	IG: Exercise Group in injured shoulder Duration: 6 weeks divided into three stages, each lasting 2 weeks. Phase 1: (1) Exercises for external and internal rotation, flexibility, and isotonic strength with 12–15 reps and 30% intensity of one-repetition maximum (1RM) for healthy shoulders. Dosage: 5 sets with 8–10 reps and 60%–70% of 1RM for healthy shoulders. Phase 2: (1) Strengthening exercises for Deltoid, Trapezius, and Serratus Anterior muscles in horizontal and diagonal axes. Focus on enhancing range of motion (ROM) and muscle strength between 90°–150° vertically, horizontally, and diagonally. Phase 3: (1) Endurance, plyometric, and strength exercises. Dosage: 5 sets with 3–6 reps using variable resistance: one at 75% of the 10RM, and two at 95% of the 1RM. (2) Extremity weights rehabilitation exercises to achieve 190°–200° ROM and equal strength in both arms. (3) Thera-Band resistance exercises used throughout the six weeks, including the four colors (red, blue, black, silver, and gold).	CG: Exercise Group in Uninjured shoulder Duration: 6 weeks divided into three stages, each lasting 2 weeks. Phase 1: (1) Exercises for external and internal rotation, flexibility, and isotonic strength with 12–15 reps and 30% intensity of one-repetition maximum (1RM) for healthy shoulders. Dosage: 5 sets with 8–10 reps and 60%–70% of 1RM for healthy shoulders. Phase 2: (1) Strengthening exercises for Deltoid, Trapezius, and Serratus Anterior muscles in horizontal and diagonal axes. Focus on enhancing range of motion (ROM) and muscle strength between 90°–150° vertically, horizontally, and diagonally. Phase 3: (1) Endurance, plyometric, and strength exercises. Dosage: 5 sets with 3–6 reps using variable resistance: one at 75% of the 10RM, and two at 95% of the 1RM. (2) Extremity weights rehabilitation exercises to achieve 190°–200° ROM and equal strength in both arms. (3) Thera-Band resistance exercises used throughout the six weeks, including the four colors (red, blue, black, silver, and gold)."	Force (Pretest vs. Posttest): FF: 4.41±4.01 vs. 121.5±12.4 ABF: 2.94±2.74 vs. 103.1±9.8 ADF: 3.84±0.34 vs. 133.7±9.26 HBF: 20.01±7.64 vs. 69.1±8.92 Range of Motion (ROM - Pretest vs. Posttest): FF: 23.8° ± 4.02° vs. 199.5° ± 0.24° ABF: 29.3° ± 3.62° vs. 195.5° ± 2.13° HBF: 30.8° ± 5.81° vs. 108.5° ± 5.72° Posttests (Injured vs. Uninjured Shoulders): FF: 121.5±12.44 vs. 128.2±10.4 ABF: 103.1±9.81 vs. 110.9±8.32 ADF: 133.7±9.26 vs. 135.2±5.33 HBF: 69.1±8.92 vs. 72.71±5.42 F.ROM: 190.5º ± 0.24º vs. 201.3º ± 1.25° AB.ROM: 195.5° ± 2.13° vs. 198.9° ± 1.06° HE.ROM: 107.8° ± 6.12° vs. 108.5° ± 5.72°	The rehabilitation program outlined in this study demonstrated effectiveness in enhancing strength and range of motion (ROM) in the injured shoulder. This is evident from the comparable posttest values observed between the injured and uninjured shoulders.

Moura et al. (2016)	Case series	n=4 (1) Amateur athletes Inclusion Criteria: (1) Presence of unilateral subacromial pain syndrome (2) Clinical evidence of scapular dyskinesis (3) Evaluation conducted at baseline (4) Follow-up assessment after six weeks of treatment	IG: Exercise Group (EG) Phase 1: Components: (1) Pain control (2) Range of motion (ROM) (3) Education in scapular control Progression Criteria: (1) Diminished pain (2) Decreased upper trapezius (UT) activation (3) Improved control of scapular movement Phase 2: (1) Periscapular muscular strengthening Initiation of sensory motor training Dosage: All exercises: 3 sets of 15 repetitions Rationale: Intermediate dosage aimed at building muscular strength and endurance Phase 3: (1) Advanced sensory motor training (2) Promotion of proper scapular alignment and stabilization at all times during activity	CG: No available	Patient 1: % Muscle Strength (a): Arm Elevation: 16.9 – 19.1 (13.1%) Internal Rotation: 32.7 – 37.8 (15.6%) External Rotation: 26.0 – 31.8 (22.5%) Range of Motion (º): Internal Rotation: 57.0 – 94.0 (64.9%) External Rotation: 93.0 – 104.0 (11.8%) % Surface EMG (b): Upper Trapezius: 17.9 – 12.6 (-29.8%) Lower Trapezius: 25.5 – 9.8 (-61.2%) Serratus Anterior: 35.3 – 68.6 (94.6%) Normalized in relation to body mass index (a) Patient 2: % Muscle Strength (a): Arm Elevation: 42.2-43.5 (3.05%) Internal Rotation: 68.5-70.9 (3.5%) External Rotation: 61.9-68.1 (10.1%) Range of Motion (º): Internal Rotation: 62.0-67.0 (8.1%) External Rotation: 99.0-92.0 (-7.1%) % Surface EMG (b): Upper Trapezius: 50.5-35.6 (-29.5%) Lower Trapezius: 71.5-51.5 (-28.0%) Serratus Anterior: 49.6-70.0 (41.0%) Normalized in relation to body mass index (a) Patient 3: % Muscle Strength (a): Arm Elevation: 24.3-33.1 (35.9%) Internal Rotation: 43.8-39.7 (-9.4%) External Rotation: 26.5-39.9 (50.5%) Range of Motion (º): Internal Rotation: 62.0-87.0 (40.3%) External Rotation: 95.0-94.0 (1.0%) % Surface EMG (b): Upper Trapezius: 15.1-81.7 (441.0%) Lower Trapezius: 24.0-59.9 (149.3%) Serratus Anterior: 33.9-43.4 (28.1%) Normalized in relation to body mass index (a) Patient 4: % Muscle Strength (a): Arm Elevation: 15.0–39.2 (161.8%) Internal Rotation: 41.8–56.9 (35.6%) External Rotation: 42.5–65.4 (54.0%) Range of Motion (º): Internal Rotation: 73.0–94.0 (28.8%) External Rotation: 94.0–91.0 (-3.2%) % Surface EMG (b): Upper Trapezius: 17.5–55.9 (219.7%) Lower Trapezius: 8.1–26.4 (226.7%) Serratus Anterior: 24.4–44.4 (81.6%) Normalized in relation to body mass index (a)	Amateur athletes presenting clinical evidence of subacromial pain syndrome coupled with scapular dyskinesis demonstrated positive responses to a rehabilitation program. The emphasis on scapular control, upper trapezius relaxation, correction of muscular imbalances, and sensory motor training proved effective. The outcomes indicate that individuals exhibiting clinical signs of subacromial pain syndrome can experience notable enhancements in pain relief, functional capacity, and muscular performance through a targeted rehabilitation program addressing scapular dyskinesis

Moeller et al. (2014)	RCT (Two-arm parallel group)	n= 39 Inclusion Criteria: (1) All participants underwent a musculoskeletal examination, encompassing special tests for subacromial impingement, rotator cuff injuries, GH instability, and labral injuries. (2) Participants were categorized into the GH injury group based on the following criteria: (3) Having at least 3 positive special tests for the aforementioned injuries. (4) Responding affirmatively to at least 2 of the following 3 questions: - Do you experience weakness, throbbing pain, pain with motion, and/or pain with overhead activities? - Do you feel looseness and/or instability in your shoulder? - Do you experience sensations of clicking, popping, cracking, snapping, and/or catching?	IG: Exercise Group (1) Multisegmented exercises are integrated, clinicians should be aware of and maintain appropriate activation between muscles that compose the scapular upward-rotation force couple (UT, LT, SA). Exercises: (1) Bow-and-arrow exercise (2) External-rotation-with-scapular-squeeze exercise (3) Lawnmower Exercise (4) Robbery Exercise	CG: Exercise Dosage: concentric phase in 3 seconds for the 4 functional rehabilitation exercises. EMG data were collected on the test extremity during the exercises. The order in which functional exercises were performed was balanced among participants.	Scapular Muscle-Activation Ratios During Functional Exercises Between Groups and Exercises: UT: MT (Bow and Arrow / External Rotation With Scapular Squeeze / Lawnmower / Robbery) Glenohumeral injury: 2.1 ± 0.3 / 0.7 ± 0.2 / 1.2 ± 0.2 / 2.2 ± 0.3 Healthy control: 2.1 ± 0.3 / 0.7 ± 0.2 / 0.6 ± 0.2 / 1.3 ± 0.3 Groups combined: 2.1 ± 0.2 / 0.7 ± 0.1/ 0.9 ± 0.1 / 1.7 ± 0.2 UT: LT (Bow and Arrow / External Rotation With Scapular Squeeze / Lawnmower / Robbery) Glenohumeral injury: 3.7 ± 0.7 / 0.9 ± 0.2 / 1.7 ± 0.3 / 3.5 ± 0.5 Healthy control: 3.1 ± 0.7 / 0.7 ± 0.2 / 0.6 ± 0.3 / 1.5 ± 0.5 Groups combined: 3.4 ± 0.5 / 0.8 ± 0.1 / 1.2 ± 0.2 / 2.5 ± 03 UT: SA (Bow and Arrow / External Rotation With Scapular Squeeze / Lawnmower / Robbery) Glenohumeral injury: 7.2 ± 1.4 / 0.8 ± 0.3 / 1.7 ± 0.4 / 3.8 ± 1.2 Healthy control: 3.3 ± 1.5/ 0.8 ± 0.3 / 0.6 ± 0.4 / 1.9 ± 1.2 Groups combined: 5.2 ± 1.0/ 0.8 ± 02 / 1.1 ± 0.3 / 2.9 ±0.8	Scapular muscle activation demonstrated comparable patterns among participants with GH injuries and their healthy counterparts during the execution of unloaded multiplanar, multi-joint exercises examined. Elevated activation ratios observed in the bow-and-arrow exercise suggest potential hyperactivity in the upper trapezius or diminished engagement of the middle trapezius, lower trapezius, and serratus anterior.

Note: RCT: Randomized Controlled Trial; ET: Exercise Therapy; MT: Manual Therapy ; GH: Glenohumeral; SHD: Scapulohumeral Dyskinesia; SIS: Subacromial Impingement Syndrome; UT: Upper Trapezius; MT: Medium Trapezius; LT: Low Trapezius; SA: Serratus Anterior; ROM: Range Of Movement.

Methodological Quality Assessment

The methodological quality of the included studies was assessed in the range of goods, with a mean of 5.85 out of 10 (SD = 1.72), as determined using the PEDro scale. All articles included in the review did not comply with blinding of participants or therapists (n = 7, 100%) [5-11]. Only one study used blinding of outcome assessors (n = 2, 28.4%) (5,10). Blinding and randomization were not completed in 64.2% of included studies (n=4) [5,7,10,11]. The assessment of the methodological quality is detailed in the (Table 3).

Table 3: Methodological Quality Assessment.

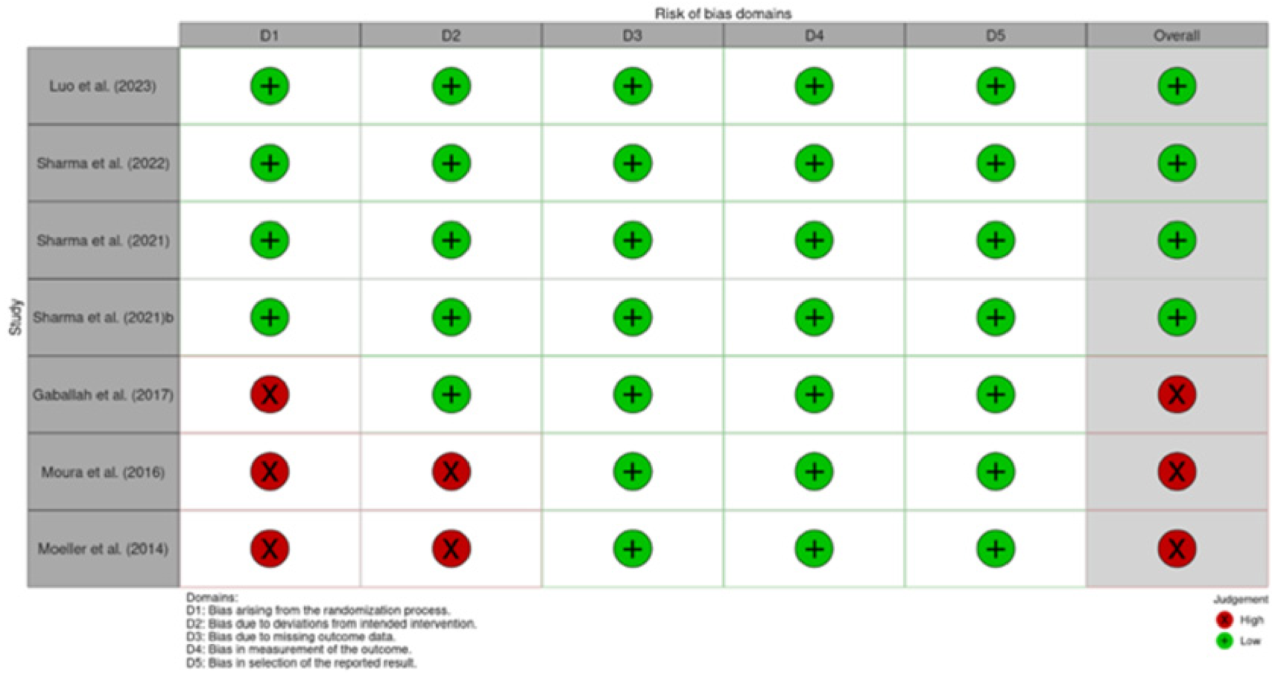
Authors, yrs	1	2	3	4	5	6	7	8	9	10	11	Total
Luo et al. (2023)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Sharma et al. (2022)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Sharma et al. (2021)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Sharma et al. (2021) b	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Gaballah et al. (2017)	Y	N	N	N	N	N	N	Y	Y	Y	Y	4
Moura et al. (2016)	Y	N	N	N	N	N	N	Y	Y	Y	Y	4
Moeller et al. (2014)	Y	N	N	N	N	N	N	Y	Y	Y	Y	4

Note: PEDro scale domains: (1) eligibility criteria were specified; (2) subjects were randomly assigned to groups (in a crossover study, subjects were randomly assigned an order in which they received treatments); (3) the assignment was concealed; (4) the groups were similar at baseline in terms of the most important prognostic indicators; (5) all subjects were blinded; (6) all therapists administering the therapy were blinded; (7) all assessors measuring at least one key outcome were blinded; (8) measures of at least one key outcome were obtained from more than 85% of subjects initially assigned to the groups; (9) all subjects for whom outcome measures were available received the treatment or control condition as assigned or, where this was not the case, data for at least one key outcome were analyzed on an 'intention-to-treat' basis; (10) the results of statistical comparisons between groups are reported for at least one key outcome; (11) The study provides both point measures and measures of variability for at least one key outcome.

Risk of bias assessment

Overall risk of bias assessed using the RoB 2 tool ranged from low to high. 42.8% of studies (n = 3) had a high risk of bias related to the randomization intervention allocation process [6,8,9]. Additionally, 28.4% (n = 2) were at high risk of bias due to deviations from the planned intervention [6,9]. The risk of bias analysis is detailed in the (Table 4).

Table 4: Cochrane Risk of Bias Tool for Randomized Trial Domains (RoB 2).



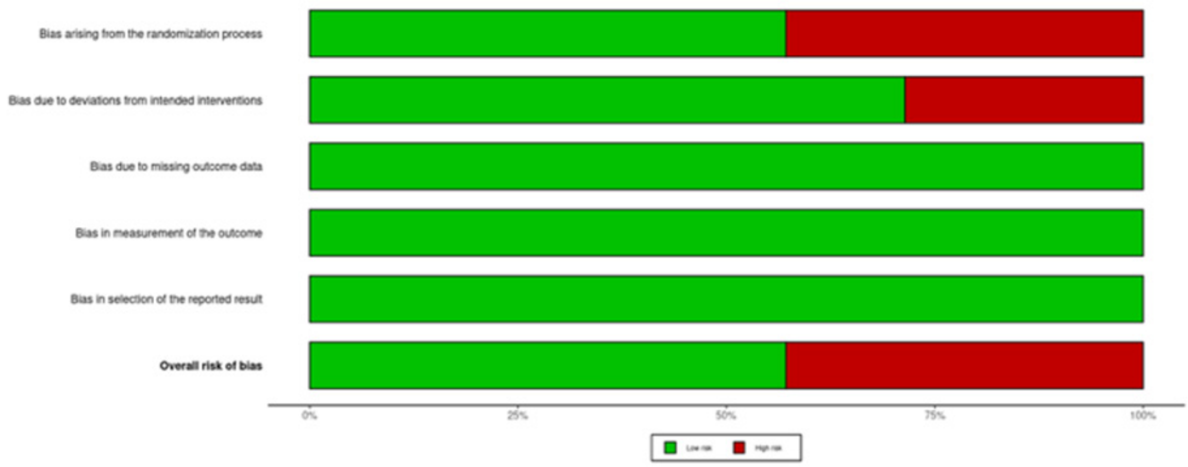


Table 4: Cochrane Risk of Bias Tool for Randomized Trial Domains (RoB 2).

Data synthesis

Efficacy of strength exercise as monotherapy in overhead athletes with scapulohumeral dyskinesia (SHD).

Muscle strength and activation

The studies included in this review concluded that the use of resistance exercise as a conservative treatment for SHD in overhead athletes is useful for partial improvement but not sufficient for complete recovery. Depending on each athlete's injury and symptoms, variables such as exercise selection, training load, timing, and content distribution must be considered. Sharma et al. (2021) showed that the mean difference in muscle activity measured from baseline to 8 weeks of intervention was significant only for the upper and middle trapezius muscles in the therapeutic exercise group. Similarly, Gaballah et al. (2017) [8] demonstrated that a physical rehabilitation protocol can improve the strength of an injured shoulder and bring it into line with that of an uninjured shoulder. Moura et al. (2016) [6] also obtained a significant improvement in muscle strength in movements with greater limitation such as elevation, internal and external rotation of the shoulder [5].

Range of Motion

The studies included in this review argue that the use of strength exercise as a conservative treatment for SHD in overhead athletes is a good ally to improve the range of motion of the shoulder. Gaballah et al. (2017) [8] demonstrated that a 6-week physical rehabilitation protocol can improve the range of motion (ROM) of the injured shoulder and bring it into line with that of the uninjured shoulder in flexion, abduction, and hyperextension movements. Moura et al. (2016) [6] also showed that an increase in ROM for internal rotation (decrease in GIRD) would favor the disappearance of risk factors such as posterior capsule stiffness and scapular dyskinesia that would lead to shoulder injury.

Muscle Activation Ratios

The studies included in this review argue that the use of strength exercise as a conservative treatment for SHD in overhead athletes can improve muscle activation rates. Luo et al. (2023) [7] showed that a specific 30 second training of the scapular muscles is sufficient for modifying activation ratios of the UT:LT (Upper Trapezius: Lower Trapezius) and UT:SA (Upper Trapezius: Serratus Anterior). Despite this, Moeller et al. (2014) [9] observed that scapular muscle activation (UT/MT/LT/SA) was similar between participants with GH injuries and healthy control participants when performing the multiplanar and multi-joint exercises without load tested, which did not produce any change in activation rates.

Scapular kinematics

The studies included in this review argue that the use of strength exercise as a conservative treatment for SHD in overhead athletes can improve scapular kinematics. Luo et al. (2023) [7] showed that resistance specific training of the scapular or strength muscles is sufficient for the upward scapular rotation to increase significantly but there were no significant effects for internal rotation and posterior inclination. Efficacy of strength exercise as polytherapy in overhead athletes with scapulohumeral dyskinesia (SHD).

Strength and Muscle Activation

The studies included in this review support the use of strength exercise as a combined treatment with other modalities in the treatment of SHD in athletes' "overhead". The study of Sharma et al. (2021) [5] showed that when TE (Therapeutic Exercise) plus MT (Manual Therapy) is performed, the mean difference in muscle activity measured from baseline to 8 weeks of intervention was significant ($p < 0.05$) for all muscles in the TE plus MT group, while only for the upper trapezius and middle trapezius in the ET group. In the same way, Sharma et al. (2021) [10] showed that mean changes in isometric strength measured from baseline to the eighth week of intervention were found to be significant for all scapular muscles in the TE plus MT group, and even showed a significantly greater increase in strength effect size than those in the TE group.

Latency Time

The studies included in this review support the use of strength exercise as a combined treatment with other modalities in the treatment of SHD in athletes overhead. Sharma et al. (2021) [5] showed that the mean difference in muscle onset latency time measured from baseline to 4th week and from baseline to post-intervention (8th week) was statistically significant in the TE plus MT group ($p < 0.05$). The TE group did not show a significant mean difference for the time to onset at both levels ($p > 0.05$). It was also observed that the muscle activity of MT, LT and SA increased, while that of UT decreased. In addition, the TE group also showed a significant increase in MT and a decrease in UT.

Pain

The studies included in this review support the use of strength exercise as a combined treatment with other modalities in the treatment of SHD in athletes' overhead. Sharma et al. (2021) [5] showed that the mean difference in SPADI-H score change was statistically significant from baseline to week 4 and from baseline to intervention after (week 8) in both the TE plus MT group and the TE group.

DHA (Acromio-Humeral Distance)

The studies included in this review support the use of strength exercise as a combined treatment with other modalities in the treatment of SHD in athletes overhead. The study of Sharma et al. (2022) [10] showed that after an 8-week intervention, the TE plus MT group showed significantly greater improvement in AHD in athletes with subacromial impingement syndrome compared to the TE group at all three angles (0º-45º-60º).

Discussion

The primary purpose of this systematic review is to identify, analyze, and summarize the existing literature on the clinical effectiveness of various physical training interventions as conservative treatments for SHD-related shoulder injuries in overhead athletes. Based on the results obtained, we can confirm that different physical exercise regimens are effective as conservative treatment of SHD, with increased activation and reorganization of the scapular muscles, restoration of normal scapular kinematics and therefore increased stability of the scapular muscles occurring in complex in the shoulder joint. Different exercise protocols have been applied in terms of exercise selection, training load, content distribution and application time, we observe that in all of them there is a significant improvement in variables related to SHD in the short term (from 30 minutes of physical exercise to 8 weeks). Despite this, Sharma et al. (2021) [5], Sharma et al. (2021) [10] and Sharma et al. (2022) [11] state that the effectiveness of this conservative treatment significantly increases its effectiveness in combination with alternative therapies such as manual therapy, especially when it comes to reestablishing the activation ratio between the Upper Trapezium (UT): Middle-Inferior Trapezium (MT/LT) and Upper Trapezium (UT): Serratus anterior (SA).

As we have observed, the effectiveness of physical exercise by itself, as monotherapy is effective, but in combination with alternative therapies such as manual therapy, it significantly increases the improvement of SHD in 6–8-week protocols, this may be due to multiple factors. First, the correct choice, combination and progression of exercises to stimulate the cortical motor reorganization of neuronal connections [13]. Second, the stimulation of the endogenous antinociceptive system that occurred after manual therapy generated deep analgesia in those muscles that were overactivated and, therefore, pain. Thirdly, the improvements in muscle strength that occur due to progressive neuronal adaptation [13]. Fourth, the biomechanical mediators, MT identifies and treats biomechanical dysfunction in order to address diagnosed movement impairment. The main potential of this study lies in the proposal of a new approach to the implementation of a physical rehabilitation protocol for SHD. It will help all those rehabilitation doctors, physiotherapists and sport trainers to obtain better results with their patients and will invite you to professional self-criticism. In the same way, it will promote a greater theoretical knowledge about SHD management (types, muscle alteration, etc.) and promote terminological unification.

The biggest limitations we found were differences in search terms, training programs to treat SHD in general or specific ways, and the level of research. The results obtained may have a direct impact on the preparation of systematic reviews. It will undoubtedly increase the standardization of terminology, protocols, assessments, and selected populations to facilitate the creation of studies with a sufficient level of evidence to normalize the application of this pathology and intervention protocols.

Conclusions

In conclusion, the results indicate that a exercise therapy program is effective as a monotherapy for the treatment of SHD and related shoulder injuries. Additionally, when combined with alternative therapies such as manual therapy, they may provide more progressive and effective benefits in increasing and reorganizing scapular muscle activation, restoring normal scapular kinematics, and thereby improving stability of the complex shoulder joint.

Acknowledgement

None.

Conflict of Interest

No Conflict of interest.

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