Review

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The Effects of Movement-Based Exercises on Sports Performance of Athletes with Scapular Dyskinesis: A Systematic Review

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Highlights

Main findings

- Movement-based exercise interventions significantly reduce shoulder pain and disability in athletes with scapular dyskinesis.
- Consistent improvements were observed in shoulder range of motion, particularly internal rotation.
- Training programs enhanced rotator cuff and scapular stabilizer strength, as well as scapulohumeral rhythm.
- Sport-specific outcomes, including throwing velocity, proprioceptive accuracy, and upper limb stability, showed notable gains.

Implications

- Effective protocols typically lasted 6–8 weeks with 2–3 sessions per week, while longer programs achieved more durable benefits.
- Findings support individualized rehabilitation strategies focusing on scapular stability and neuromuscular control to optimize athletic performance and prevent injury.

Abstract

Background: Scapular dyskinesis is a common dysfunction among athletes, particularly in overhead sports, leading to pain, reduced range of motion (ROM), and impaired performance. Movement-based exercises are increasingly used to address these issues, but their overall impact on sports performance remains unclear. **Objective:** This systematic review aims to evaluate the effects of movement-based exercises on sports performance in athletes with scapular dyskinesis. **Methods:** A comprehensive search was conducted in Web of Science, Scopus, and PubMed up to July 30, 2025, following PRISMA guidelines. Data were extracted and assessed for risk of bias using RoB-2 and ROBINS-I tools. A narrative synthesis was performed due to study heterogeneity. **Results:** Fourteen studies (8 RCTs, 6 non-RCTs) comprising 412 athletes (mean age 23.8 ± 3.1 years) were included. Interventions ranged from 6 to 24 weeks and primarily targeted scapular stabilization, neuromuscular control, and proprioception. Across studies, exercise interventions led to consistent reductions in pain and disability, with sustained improvements observed in long-term protocols. Significant gains were reported in ROM (particularly internal rotation), rotator cuff and scapular stabilizer strength, and scapulohumeral rhythm. Several trials also documented enhanced functional performance, including throwing velocity, proprioceptive accuracy, and sport-specific outcomes. Overall, 6–8-weeks programs with two to three sessions per week were effective, while longer or more intensive protocols yielded more durable benefits. **Conclusion:** Movement-based exercises are effective in enhancing sports performance and reducing disability in athletes with scapular dyskinesis.

Tailored rehabilitation programs focusing on scapular stability and neuromuscular control are recommended for optimal outcomes.

Keywords: scapular dyskinesis; movement-based exercises; sports performance; rehabilitation; athletes

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1. Introduction

Scapular dyskinesis, characterized by abnormal scapular motion during shoulder movements, is a prevalent condition among athletes, particularly those engaged in overhead sports such as baseball, volleyball, and tennis [1–3]. This dysfunction can lead to compromised shoulder mechanics, resulting in pain, decreased range of motion (ROM), and impaired athletic performance [4,5]. The shoulder complex is crucial for various athletic activities, and any dysfunction can significantly hinder an athlete's ability to perform optimally [6]. The scapula plays a vital role in shoulder stability and mobility, serving as the foundation for the glenohumeral joint [2]. Proper scapular mechanics are essential for effective force transmission during upper extremity movements [7]. When dyskinesis occurs, it can disrupt the normal scapulohumeral rhythm, leading to altered muscle activation patterns, increased strain on the shoulder joint, and a higher risk of injury [7,8]. Athletes with scapular dyskinesis often report symptoms such as shoulder pain, weakness, and functional limitations, which can adversely affect their training and competitive performance [3,9]. Recent studies have highlighted the importance of addressing scapular dyskinesis through targeted rehabilitation strategies [10,11]. Movement-based exercises, which focus on enhancing scapular stability, strength, and coordination, have emerged as a promising intervention for athletes suffering from this condition [12–14]. These exercises aim to restore normal scapular mechanics, thereby improving shoulder function and overall sports performance [10,15–17]. Various modalities, including resistance training, proprioceptive exercises, and neuromuscular re-education, have been employed to target the underlying deficits associated with scapular dyskinesis [18–20]. Despite the growing body of literature, a comprehensive synthesis of the available evidence regarding the impact of movement-based exercises on sports performance in athletes with scapular dyskinesis is lacking. Previous reviews have often focused on specific exercise protocols or individual outcomes, leaving a gap in understanding the broader implications of these interventions [10,18]. This systematic review aims to fill this gap by critically evaluating and summarizing the findings of relevant studies. By examining the effects of various movement-based interventions on key performance metrics, including pain reduction, ROM, muscle strength, and functional outcomes, this review seeks to provide a clearer understanding of how these exercises can benefit athletes with scapular dyskinesis.

2. Materials and Methods

2.1. Protocol Registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [21] (Supplementary File S1) and is registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD42025635493.

2.2. Search Strategy

A thorough systematic search was conducted across Web of Science, Scopus, and PubMed databases from their inception through July 30, 2025. Two independent reviewers carried out the searches, with any disagreements resolved through discussion or, when necessary, consultation with a third reviewer. The search strategy combined MeSH terms and free-text keywords using both AND and OR operators to ensure comprehensive coverage. The specific search strategies are detailed in Table 1. No restrictions were applied regarding study design or publication status. Additionally, reference lists of included articles were screened to identify further relevant studies, supplemented by a grey literature search via Google Scholar. The Connected Papers platform was also employed to capture any additional pertinent publications (https://www.connectedpapers.com/).

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Table 1. Search strategy.

Database	Complete search strategy
Web of Science	athlet* OR sport* OR sportsman* OR sportswoman* OR sportsperson* (Topic) AND exercis* OR train* OR rehabilitat* OR physiotherap* OR "therapeutic exercise" (Topic) AND perform* OR strength* OR mobil* OR "range of motion" OR endurance OR function* OR skill* OR agility OR speed OR power OR injur* OR fatigue OR strength (Topic) AND "scapular dyskinesis" OR "scapular dyskinesia" OR scapul* (Topic)
Scopus	(TITLE-ABS-KEY (athlet* OR sport* OR sportsman* OR sportswoman* OR sportsperson*) AND TITLE-ABS-KEY (exercis* OR train* OR rehabilitat* OR physiotherap* OR "therapeutic exercise") AND TITLE-ABS-KEY (perform* OR strength* OR mobil* OR "range of motion" OR endurance OR function* OR skill* OR agility OR speed OR power OR injur* OR fatigue OR strength) AND TITLE-ABS-KEY ("scapular dyskinesis" OR "scapular dyskinesia" OR scapul*))
PubMed	(((athlet*[Title/Abstract] OR sport*[Title/Abstract] OR sportsman*[Title/Abstract] OR sportswoman*[Title/Abstract] OR sportsperson*[Title/Abstract]) AND (exercis*[Title/Abstract] OR train*[Title/Abstract] OR rehabilitat*[Title/Abstract] OR physiotherap*[Title/Abstract] OR "therapeutic exercise"[Title/Abstract])) AND (perform*[Title/Abstract] OR strength*[Title/Abstract] OR mobil*[Title/Abstract] OR "range of motion"[Title/Abstract] OR endurance[Title/Abstract] OR function*[Title/Abstract] OR skill*[Title/Abstract] OR agility[Title/Abstract] OR speed[Title/Abstract] OR power[Title/Abstract] OR injur*[Title/Abstract] OR fatigue[Title/Abstract] OR strength[Title/Abstract])) AND ("scapular dyskinesis"[Title/Abstract] OR "scapular dyskinesia"[Title/Abstract] OR scapul*[Title/Abstract])

2.3. Eligibility Criteria and Study Selection

After completing the search, all identified studies were imported into EndNote Reference Library (Version 20; Clarivate Analytics, Thomson Reuters Corporation, Philadelphia, Pennsylvania) where duplicates were meticulously identified and removed. The refined list of studies was then transferred to the Rayyan web application (Rayyan Systems, Inc., Cambridge, MA, USA) [22] for screening. Within Rayyan, each study underwent a detailed evaluation based on its title, abstract, and full text when necessary. Any studies deemed irrelevant during this preliminary screening had their exclusion reasons carefully recorded. Two independent reviewers subsequently conducted a thorough full-text review of studies that met initial criteria, applying the PICOS framework [23] (Population, Intervention, Comparison, Outcome, and Study design) to guide inclusion and exclusion decisions, as outlined in Table 2. When disagreements occurred during this process, a third reviewer was consulted to reach a consensus on whether to include or exclude the contested studies.

Table 2. Eligibility criteria based on PICOS strategy.

	Inclusion criteria	Exclusion criteria
Population	Athletes with diagnosis of scapular dyskinesis	Athletes with scapular dyskinesis and concurrent injuries (e.g., rotator cuff tendinopathy, superior labrum anterior to posterior lesions, labral tears).

		Scapular dyskinesis in non-athletic populations.
Intervention	Movement-based interventions, such as physical activity and other methods that involve active movement.	Other interventions occurring simultaneously.
Comparison	Studies investigating the effects of a exercise protocol compared to a control condition (e.g., no exercise or a placebo intervention) as the primary comparison.	Studies without a control condition.
Outcome	Pain intensity during activity or at rest should be assessed using the Visual Analog Scale or Numeric Rating Scale, while objective sport-performance metrics relevant to athletic activity, such as jump height, muscle activity measured by electromyography, velocity, and other sport-specific performance measures, should also be collected.	Absence of measurements for pain intensity or performance-related outcomes.
Study design	RCTs and non-RCTs.	Single-group intervention; Case studies; Reviews.

2.4. Data Extraction

From the included papers, study details (author, year of publication, location), study design, sample description (sample size, sex, age, and scapula dyskinesis type), exercise characteristics of experiment and control group, sports performance measures, and main outcomes position were extracted by two authors. For missing or inconsistent data, study authors were contacted via email (up to three attempts, with a 72-hour interval between attempts) and through ResearchGate when applicable. If no response was received after the third attempt or the requested data were not provided, the study outcome was excluded from further analysis.

2.5. Quality Assessment

The assessment of risk of bias in the included studies was conducted in accordance with Cochrane guidelines. Specifically, the ROBINS-I tool was employed to evaluate non-randomized controlled trials (non-RCTs), while the RoB-2 tool was used for randomized controlled trials (RCTs). Two reviewers independently appraised the studies by examining all relevant domains: the seven domains covered by ROBINS-I, including confounding, selection of participants, classification of interventions, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results; and the five domains of RoB-2, with an additional focus on bias related to the randomization process for RCTs. Both tools provided structured guidance and signaling questions to support transparent and consistent judgments, with categories such as "Low risk of bias," "High risk of bias," "Some concerns" or "Moderate," and "Unclear risk of bias" or "No information," alongside detailed explanatory notes. To visually summarize the findings of the bias assessment, traffic light plot and summary plot were generated using the

Robvis visualization tool (www.riskofbias.info) [24], in line with Cochrane's recommendations for clear presentation of risk of bias results.

2.6. Data Synthesis

This study employed a narrative approach to data synthesis to provide a thorough and transparent account of the findings. To uphold methodological rigor and improve the credibility and trustworthiness of the results, the review strictly adhered to the PRISMA statement guideline [21]. Given the heterogeneity in outcome measures among the included studies, performing a meta-analysis was deemed inappropriate and not possible. Consequently, the review utilized a Synthesis Without Meta-Analysis (SWiM) guideline [25], a method previously employed in systematic reviews [26,27], to ensure clarity and consistency in the presentation of synthesized evidence. Additionally, prior to the data merging, the level of agreement between reviewers at each stage of the evaluation process was systematically assessed using Kappa (κ) statistics. The strength of agreement was categorized into distinct levels: poor ($\kappa \leq 0.20$), fair ($\kappa = 0.21$–0.40), moderate ($\kappa = 0.41$–0.60), substantial ($\kappa = 0.61$–0.80), or near-perfect ($\kappa = 0.81$–0.99) [28].

3. Results

3.1. Study Identification

Based on the PRISMA guideline [21], the initial search across electronic databases identified 1716 records. After removing 685 duplicates (40.0%), 1031 unique studies remained for screening against the inclusion and exclusion criteria. During the title and abstract review, 1008 studies (97.8%) were excluded as irrelevant, leaving 23 articles (1.3%) for full-text assessment. Of these, 9 studies were excluded for specific reasons outlined in Supplementary File S2. Ultimately, 14 studies were included in the systematic review. Inter-rater agreement was perfect ($\kappa = 0.91$), confirming consistent bias assessments across reviewers. These studies specifically examined the impact of movement-based exercise interventions on the sports performance of athletes with scapular dyskinesis. The flow of studies through each screening stage is illustrated in the PRISMA diagram (Figure 1).

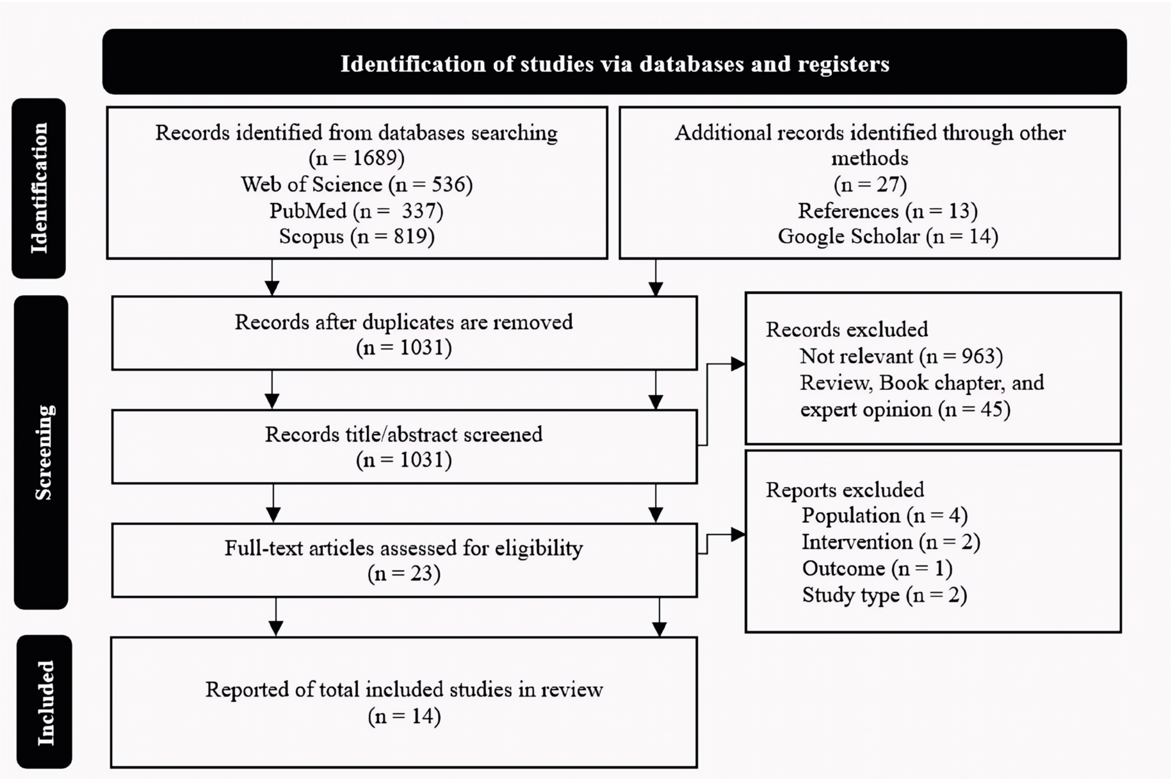

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flow diagram for new systematic reviews, including searches of databases and registers.

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3.2 Descriptive Characteristics of the Included Studies

The fourteen studies included in this systematic review, published between 2010 and 2025, encompassed 412 participants. Among the 373 participants with reported sex distribution, 242 (64.9%) were male and 131 (35.1%) were female. Among these studies, eight were randomized controlled trials (RCTs) conducted in Iran (n=3), Germany (n=1), Greece (n=1), the United Kingdom (n=1), China (n=1), and South Korea (n=1). The other six studies were non-randomized controlled trials conducted in Italy (n=3), Brazil (n=1), South Korea (n=1), and Iran (n=1). Sample sizes across the included studies ranged from 4 to 54 participants. The pooled mean age of participants was 23.8 ± 3.1 years. Table 3 provides a detailed overview of the characteristics of the included studies.

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Table 3. Characteristics of the included studies.

Study details	Study design	Sample description	Exercise characteristics of EG	CG intervention	Sports performance measures	Main outcomes
Wen et al., (2025) [5] China	RCT	N=32 Sex=32 males Age=20.8 ± 2.4 years SD type=NA	D=8 weeks F=3 per week I=NA T=NA minutes T=EG1: Scapular dyskinesisbased exercise therapy; EG2: Multimodal physical therapy	NA	Pain, ROM, strength, disability index, scapular kinematics	Disability improved in both groups by week 8 ($p < 0.001$) and remained only in SDBET at week 12 ($p < 0.001$). Pain reduced more in MPT at week 8 ($p = 0.018$) but not at week 12 ($p = 0.268$). Active ROM improved in both groups by week 8 and remained only in SDBET at week 12 ($p < 0.001$). Strength improved only in SDBET at weeks 8 and 12 ($p < 0.001$). Scapular kinematics improved in 43.8% of SDBET participants, with no change in MPT ($p = 0.001$–0.004).
Gholamian et al., (2024) [13] Iran	RCT	N=30 Sex=30 males Age=26.3 ± 1.4 years SD type=NA	D=8 weeks F=3 per week I=NA T=NA minutes T=Functional exercises	Regular tennis training and daily activities	Scapular brachial rhythm, upper limb function	The results indicated that functional exercises significantly improved scapulohumeral rhythm at 0° ($p = 0.004$), 45° ($p < 0.001$), 90° ($p < 0.001$), and 135° ($p < 0.001$), as well as upper limb function ($p = 0.002$) in the experimental group.
Karimi and Firouzjah, (2024) [14] Iran	RCT	N=30 Sex=30 females Age=22.7 ± 2.6 years SD type=NA	D=8 weeks F=3 per week I=NA T=40 minutes T=Scapular stabilization exercises	Usual daily activities	Specific performance, Shoulder position, Pain	Training led to significant improvements in shoulder position and performance ($p = 0.001$ for both). The control group also showed performance gains at eight weeks. After adjusting for pre-test scores, post-test differences favored the exercise group in shoulder position ($p = 0.001$) and performance ($p = 0.02$). Training also reduced dominant shoulder pain, reinforcing between-group differences at post-test.
Khakpourfard et al., (2023) [12] Iran	RCT	N=30 Sex=30 males Age=26.8 ± 5.5 years SD type=NA	D=8 weeks F=3 per week I=NA T=25-30 minutes T=suspension training	NA	Internal and external rotator muscle strength, functional stability, proprioception	There were significant time-by-group interactions for internal rotator strength, external rotator strength, functional stability, and shoulder proprioception accuracy ($p = 0.001$), indicating that changes over time differed between groups. In addition, there were significant main effects of time and of training across all variables. Specifically, internal rotator strength showed significant effects of time ($p = 0.005$) and training ($p = 0.021$); external rotator strength showed time ($p = 0.003$) and training ($p = 0.009$); functional stability improved with both time ($p = 0.001$) and training ($p = 0.001$); and proprioception accuracy improved with time ($p = 0.001$) and training ($p = 0.001$).
Paraskevopoulos et al., (2022) [31] Greece	RCT	N=39 Sex=NA Age=21.8 ± (NA) years SD type=NA	D=6 weeks F=3 per week I=NA T=60 minutes T=EG1: kinetic chain approach; EG2: mirror cross exercise	NA	Functional throwing performance index Throwing performance (velocity, strength)	The Functional throwing performance Index and throwing velocity significantly improved in both the kinetic chain approach ($p < 0.011$ and $p = 0.001$) and mirror cross exercise ($p = 0.004$ and $p < 0.001$) groups, with no changes in controls. Throwing force increased significantly only in the mirror cross exercise group ($P = 0.011$).
Study details	Study design	Sample description	Exercise characteristics of EG	CG intervention	Sports performance measures	Main outcomes

Naderifar and Ghanbari, (2022) [35] Iran	Non-RCT	N=54 Sex=54 females Age=22.2 ± 2.4 years SD type=NA	D=8 weeks F=3 per week I=moderate T=NA minutes T=Selected Corrective Exercises	Typical training regimen	Internal and external rotation ROM	Results revealed that, in the experimental group, glenohumeral internal rotation significantly increased (p = 0.001) following the exercise program. No significant changes were observed in the control group.
Song et al., (2020) [34] Republic of Korea	Non-RCT	N=27 Sex=27 males Age=19.6 ± 1.9 years SD type=Sick	D=8 weeks F=3 per week I=NA T=40 minutes T=Scapular KineticChain Exercise	NA	Muscle activation	Maximal and mean muscular activation significantly increased after exercise in Normal-Dominant and SICK-Dominant upper and lower trapezius muscles (p < 0.05). The SICK-Dominant serratus anterior showed lower activation than Normal-Dominant at pre-test (p = 0.034), with differences persisting post-test compared to Normal-Non-Dominant (p = 0.031)
Sant et al., (2018) [29] United Kingdom	RCT	N=25 Sex=25 males Age=23.2 ± 3.6 years SD type= Unilateral	D=NA weeks F=NA per week I=NA T=NA minutes T=Prehabilitation	Usual routine	Functional throwing performance index, power, upper extremity stability	Pain was reported in 3 athletes in the control group versus 1 in the study group (p = 0.59). Athletes receiving prehabilitation showed significantly greater improvements in external rotation (p = 0.01) and internal rotation (p = 0.03) compared to controls. No significant differences were found between groups in functional tests, scores, or abduction strength.
Ilyoung et al., (2018) [32] Republic of Korea	RCT	N=24 Sex=24 males Age=25.7 ± 1.4 years SD type= Inferomedial winging and medial border winging	D=6 weeks F=3 per week I=70%-90% stretch T=NA minutes T=EG1: PSSE group; EG2: SSE	NA	Isokinetic peak moment/body weight, ROM, Pain	Significant time × group interactions were found for concentric and eccentric external rotation peak moment/body weight (p = 0.039, p = 0.008), ERe to IRc ratio (p = 0.025), and rotation ROM (IRROM p < 0.001, ERROM p = 0.001). The PSSE group showed improvements at 6 weeks in ERc, ERe, ERe/IRc ratio, IRROM (↑15°), ER ROM (↓12°), and GIRD (↓17°); the SSE group did not show significant changes in strength or ROM. Pain decreased over time in both groups (p < 0.001) with no group interaction (p = 0.56).
Nowotny et al., (2018) [30] Germany	RCT	N=28 Sex=16 males and 12 females Age=33 ± (NA) years SD type=type I	D=6 weeks F= 2per week I=NA T=60 minutes T= specific exercise	Massage Therapy	ROM, Pain, disability, Scapular kinematics, shoulder function	Both exercise and massage reduced pain (VAS: exercise p = 0.007; control p = 0.004), but only the exercise group showed significant improvement in shoulder function (QuickDASH p = 0.001; SICK Scapula p = 0.003; Hand Press-up p = 0.026).
Moura et al., (2016) [33] Brazil	Non-RCT	N=4 Sex=2 males and 2 females Age=24.7 ± (NA) years type=NA	D=1 session F=NA I=NA T=120 minutes T=Specific training	NA	ROM, pain, sports performance, muscle activation, strength, function	Participants showed reduced pain, improved function and performance, increased shoulder strength, greater ROM, and enhanced serratus anterior activation.
Merolla et al., (2010) [15] Italy	Non-RCT	N=29 Sex=18 males and 11 females Age=23 ± 4.2 years SD type=NA	D=24 weeks F=NA I=NA T=NA T=Rehabilitation program for restoring scapular muscular control and balance	NA	Strength, pain, ROM	Muscle strength of the supraspinatus and infraspinatus, measured by EC and IST tests, significantly increased at 3- and 6-months post-rehabilitation (p < 0.01). Additionally, glenohumeral internal rotation ROM improved at both time points. Patient pain intensity decreased significantly from 7.5 ± 2.3 at baseline to 3.4 ± 1.8 at 3 months and 2.9 ± 2.1 at 6 months (p < 0.01).

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Study details	Study design	Sample description	Exercise characteristics of EG	CG intervention	Sports performance measures	Main outcomes
Merolla et al., (2010) [16] Italy	Non-RCT	N=29 Sex=16 males and 13 females Age=23 ± 4.5 years SD type=NA	D=24 weeks F=NA I=NA T=NA T=Rehabilitation program for restoring scapular muscular control and balance	NA	ROM, strength	Isometric strength of the infraspinatus muscle, assessed using the infraspinatus strength test, significantly increased after 6 months—3.3 ± 1.54 kg for examiner 1 ($p = 0.0069$) and 3.9 ± 1.6 kg for examiner 2 ($p = 0.0058$). The mean difference between infraspinatus strength test and the infraspinatus scapular retraction test results at 6 months was not statistically significant ($p = 0.061$). Glenohumeral internal rotation also showed significant improvement, increasing from 54.5 ± 9.8 to 67.3 ± 10.1 degrees for examiner 1 ($p = 0.0096$) and from 53.9 ± 10.2 to 68.1 ± 11.4 degrees for examiner 2 ($p = 0.0089$)
Merolla et al., (2010) [17] Italy	Non-RCT	N=31 Sex=22 males and 9 females Age=22 ± 2.5 years SD type=NA	D=24 weeks F=NA I=NA T=NA T=Rehabilitation program for restoring scapular muscular control and balance	NA	Pain, strength	The mean force values of the infraspinatus strength test increased significantly after 3 months ($p < 0.01$) and 6 months ($p < 0.001$) of rehabilitation. The mean difference between infraspinatus strength test and the infraspinatus scapular retraction test decreased from 4.72 ± 0.007 at baseline to 1.2 ± 0.26 at 3 months and 0.4 ± 0.006 at 6 months. Mean pain scores were 2.4 ± 1.8 at 3 months and 2.6 ± 1.4 at 6 months.

Descriptions: N: number of participants, F: frequency, I: intensity, D: duration, T: time, IG: intervention group, CG: control group, NA: not applicable, RCT: randomized controlled trial, SD: scapular dyskinesis, ROM: range of motion, IRROM: Internal Rotation Range of Motion, ERROM: External Rotation Range of Motion, SDBET: scapular dyskinesis-based exercise therapy, PSSE: posterior shoulder stretch combined with a scapular stabilization exercise, SSE: scapular stabilization exercise without stretching, MPT: multimodal physical therapy.

3.2. Effects of Exercises on Sports Performance

This systematic review analyzed studies investigating a wide range of variables related to sports performance, pain, ROM, muscle strength, scapular kinematics, and upper limb function. The overall findings for each category are summarized below:

3.2.1. Upper Limb Function and Performance

Multiple studies have reported improvements in upper limb function and stability following exercise interventions. Sant et al. (2018) observed increases in functional stability and upper limb strength after pre-treatment interventions, although no statistically significant differences were found between groups [29]. meanwhile, in the study by Nowotny et al. (2018), scapula-focused exercises specifically led to greater improvements in shoulder function [30]. Regarding shoulder positioning and specialized functional performance, Karimi and Firouzjah (2024), reported significant improvements in shoulder posture and related functional outcomes following an exercise program, which were statistically superior to the control group [14]. Additionally, Khakpourfard et al. (2023), documented significant enhancements in functional stability and shoulder proprioceptive accuracy post-intervention, indicating improved neuromuscular control [12]. In the domain of throwing performance, Paraskevopoulos et al. (2022), reported significant increases in throwing performance index and velocity in both intervention groups; however, increased throwing strength was observed only in the Motor Control Exercise group [31].

3.2.2. Range of Motion

Improvement in ROM was a consistent finding across multiple studies, although the extent and durability of these gains varied among protocols. Wen et al. (2025) reported that both the Scapular Dyskinesis–Based Exercise Therapy group and the Multimodal Physical Therapy group showed improvements in active ROM by week 8. However, only the Scapular Dyskinesis–Based Exercise Therapy group was able to sustain these improvements after the intervention period [5]. Similarly, Naderifar and Ghanbari (2022), reported significant improvements, particularly in shoulder internal rotation ROM [14], while Sant et al. (2018) found significant gains in both internal and external rotation [29]. Ilyoung et al. (2018), documented a 15° increase in internal rotation ROM accompanied by a reduction in external rotation ROM and a decrease in glenohumeral internal rotation deficit, suggesting a targeted adaptive response [32]. Moura et al. (2016) also reported improvements in internal rotation ROM and over a longer time frame [33]. Merolla et al. (2010), demonstrated significant increases in glenohumeral internal rotation ROM in two separate studies, with these gains maintained at 3- and 6-month follow-ups [15,16].

3.2.3. Muscle Activity and Strength

Several studies have reported significant changes in muscle activity and strength following exercise interventions targeting the shoulder complex. Song et al. (2020) documented a significant increase in upper and lower trapezius muscle activity post-intervention. In the SICK-Dominant group, changes in serratus anterior muscle activity were observed before and after training, with these differences persisting after the intervention [34]. Moura et al., (2016), also reported improvements in serratus anterior muscle activation [33].

Regarding muscle strength, Wen et al. (2025), observed increases in isometric strength exclusively in the Scapular Dyskinesis–Based Exercise Therapy group [5]. Similarly, Khakpourfard et al. (2023), reported significant gains in internal and external rotator muscle strength [12]. Moura et al. (2016) documented enhanced strength of shoulder extensors and external rotators [33]. Ilyoung et al. (2018), found a significant increase in peak isokinetic torque of external rotation in the Progressive Scapular Stabilization Exercise group, while the Scapular Stabilization Exercise group showed no significant changes [32]. Furthermore, Merolla et al. (2010), in three independent studies,

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demonstrated sustained increases in supraspinatus and infraspinatus muscle strength at 3- and 6-month follow-ups post-rehabilitation [15–17].

3.2.4. Scapular Kinematics

Numerous studies have demonstrated significant improvements in scapular kinematics and scapulohumeral rhythm following exercise interventions. Wen et al. (2025) reported that 43.8% of participants in the Scapular Dyskinesis–Based Exercise Therapy group showed significant improvements in scapular kinematics [5]. Gholamian et al. (2024), noted enhancements in scapulohumeral rhythm and upper limb function after their exercise program [13]. Likewise, Naderifar and Ghanbari (2022), observed a significant reduction in scapular dyskinesis following corrective interventions [35]. Similarly, Nowotny et al. (2018), reported a marked decrease in the prevalence of scapular dyskinesis after a training period [30].

3.2.5. Pain and Disability

Several studies have reported significant reductions in pain and disability. In an 8-week program with three sessions per week, Wen et al. (2025), observed pain reduction in both the Scapular Dyskinesis–Based Exercise Therapy group and the Multimodal Physical Therapy group; however, only Dyskinesis–Based Exercise Therapy maintained this improvement at the 12-week follow-up, indicating greater long-term effectiveness [5]. Similarly, Karimi and Firouzjah (2024), reported significant reductions in dominant-shoulder pain compared to the control group following an 8-week scapular stabilization exercise program (40 minutes per session) [14]. Khakpourfard et al. (2023), also demonstrated pain reduction after an 8-week suspension-based exercise program with shorter session durations (25–30 minutes) [12]. Moura et al., (2016), reported pain reduction in all participants after a 6-week rehabilitation program with only two sessions per week, despite the lower session frequency [33]. In contrast, Sant et al. (2018), observed a reduction in pain following pre-treatment, but this change was not statistically significant, possibly due to insufficient treatment intensity or duration [29]. In higher-intensity protocols, Ilyoung et al. (2018), compared two 6-week programs with seven sessions per week and stretching intensities of 70–90%, reporting significant pain reductions in both groups but no meaningful differences between them, suggesting that while higher intensity can facilitate pain reduction, the specific exercise modality may be less critical [32]. Finally, Merolla et al. (2010) reported a significant reduction in pain at both 3- and 6-month follow-ups following a 24-week rehabilitation program, demonstrating sustained long-term effects [15,17]. Nowotny et al. (2018) reported a significant reduction in pain levels on the visual analog scale in both the exercise ($p = 0.007$) and control ($p = 0.004$) groups, while a significant improvement in QuickDASH scores was observed only in the exercise group ($p = 0.001$) [30].Overall, 6- to 8-week programs with two to three sessions per week typically yield significant pain reduction; however, programs with longer follow-up periods or optimized training intensity tend to produce more durable and clinically meaningful outcomes. Table 4 summarizes the changes in pain and sports performance parameters resulting from exercise-based interventions.

Table 4. Changes in pain and sports performance parameters influenced by exercise-based interventions.

Parameters	Number of studies	Significant negative effect	Significant positive effect	No significant effect
Upper limb function and performance	4/14 studies	NA	[12,14,29–31]	NA
Range of motion	6/14 studies	NA	[5,15,16,32,33,35]	NA
Muscle activity and strength	8/14 studies	NA	[12,15–17,32–34]	NA
Scapular kinematics	4/14 studies	NA	[5,13,30,35]	NA
Pain and disability	8/14 studies	[5,12,14,30,32,33]		[29]

Descriptions: NA: not applicable.

3.3. Quality Assessment

Among included studies in this review, 8 were RCTs evaluated using the RoB-2 tool [5,12–14,29–32] (Figure 2), while the remaining six non-RCTs were assessed with the ROBINS-I tool [15–17,33–35] (Figure 3). According to the overall RoB-2 assessment, five of the eight randomized controlled trials (62.5%) were rated as having a low risk of bias [5,12,29,31,32]. whereas three studies (37.5%) were classified as having some concerns [13,14,30]. In the domain of bias arising from the randomization process, four studies (50%) were rated as low risk (5, 13, 31, 32). while four studies (50%) showed some concerns [12,14,29,30]. Regarding Domain 2 (Bias due to deviations from intended interventions), four studies (50%) were rated as low risk [5,12,31,32], while four studies (50%) showed some concerns [13,14,29,30]. For bias due to missing data, seven studies (87.5%) were rated as low risk [5,12,14,29–32], and one study (12.5%) was rated as some concerns [13]. In the domain of bias in the measurement of outcomes, Five studies (62.5%) demonstrated a Low risk [5,12,29–31], whereas three studies (37.5%) had a some concerns [13,14,32]. Finally, for bias in the selection of the reported result, all eight randomized controlled trials (100%) were rated as low risk. [5,12–14,29–32]. The six non-randomized controlled trials, assessed with ROBINS-I, demonstrated varied risk profiles. In Domain 1 (bias due to confounding), 57.1% of studies were rated moderate risk, [15–17,34], 14.3% low risk [35], and 14.3% high risk [33], highlighting significant challenges in controlling confounding variables and emphasizing the need for cautious interpretation of the results All studies (100%) were rated low risk in Domain 2 (bias in selection of participants) and Domain 3 (bias in classification of interventions) [15–17,33–35]. reflecting rigorous participant selection and accurate classification. Domain 4 (bias due to deviations from intended interventions) was also low risk across all studies (100%), indicating strong adherence to study protocols [15–17,33–35]. In Domain 5 (bias due to missing data), all studies were rated as low risk (15-17, 33-35). suggesting effective data management in most cases. Domain 6 (bias in measurement of outcomes) had 83.3% of studies at moderate risk [15–17,34,35], and 14.3% at high risk [33]. indicating potential concerns regarding measurement accuracy. Finally, Domain 7 (bias in selection of the reported result) was low risk for all studies (100%), demonstrating transparent and comprehensive reporting practices [15–17,33–35]. Inter-rater agreement was perfect (κ = 1.0), confirming consistent bias assessments across reviewers.

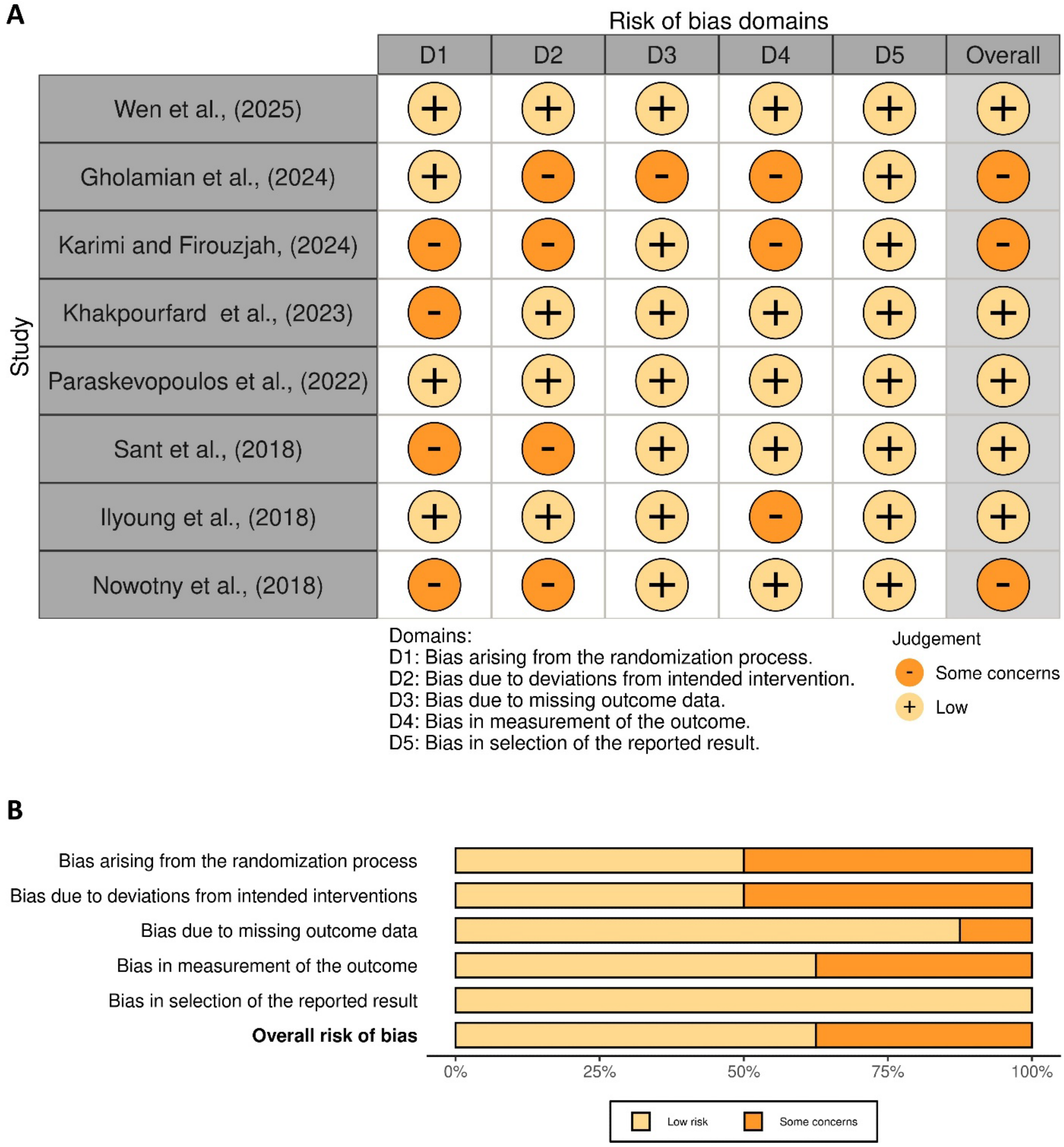

Figure 2. Summary of risk of bias among the included RCTs assessed via ROB-2. A: Traffic light plot; B: Summary plot.

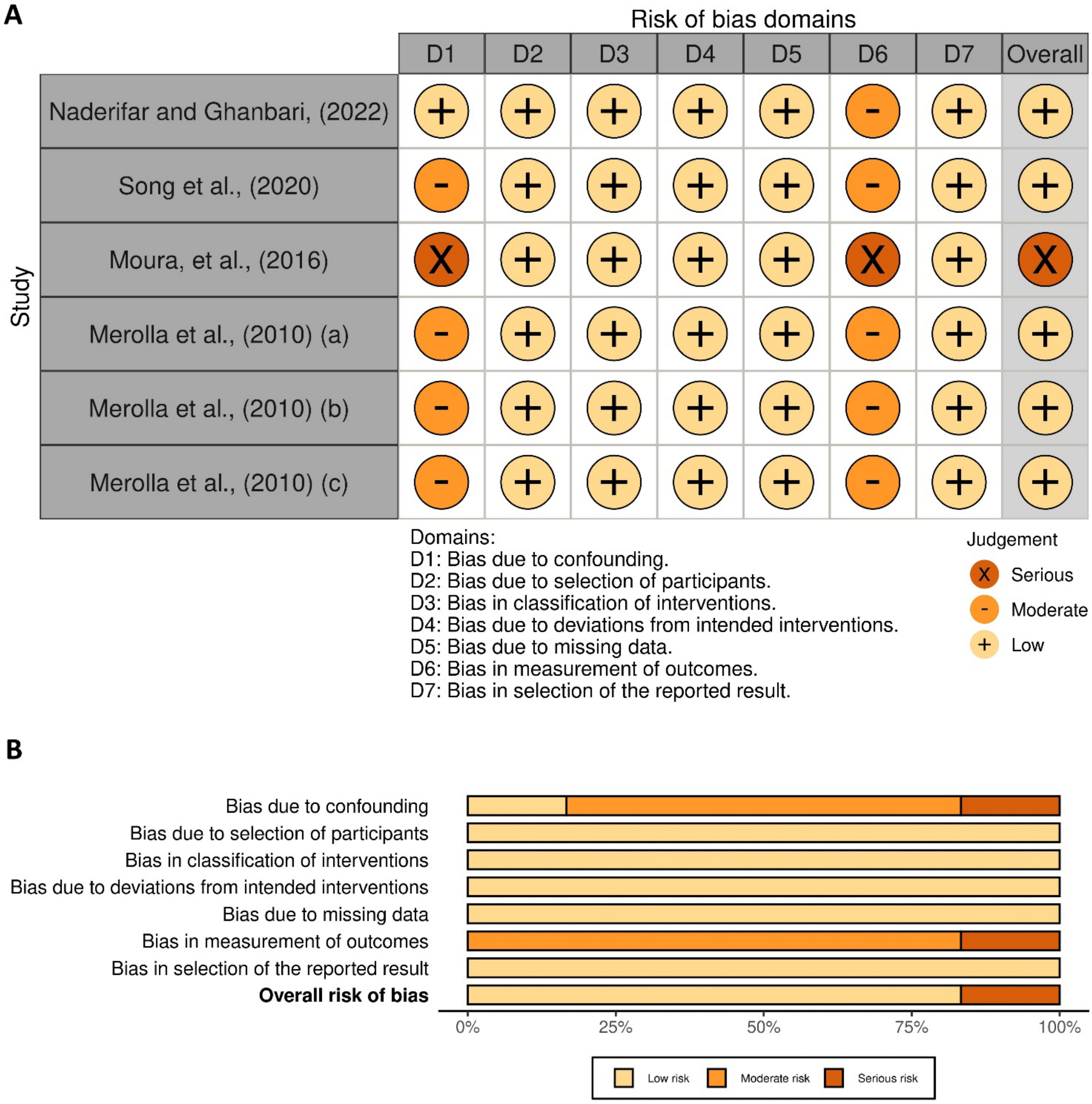

Figure 3. Summary of risk of bias among the included non-RCTs assessed via ROBINS-I. A: Traffic light plot; B: Summary plot.

4. Discussion

This systematic review aimed to evaluate the effects of movement-based exercises on sports performance in athletes with scapular dyskinesis. The findings from the included studies suggest that targeted exercise interventions can lead to significant improvements in various performance metrics, including pain reduction, ROM, muscle strength, and overall upper limb function. These results underscore the importance of addressing scapular dyskinesis in athletic populations to enhance performance and reduce the risk of injury.

4.1. Impact on Pain and Disability

One of the most consistent findings across the studies was the significant reduction in pain associated with movement-based exercise interventions. Pain is a common symptom experienced by

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athletes with scapular dyskinesis, often resulting from altered biomechanics and compensatory movement patterns that place excessive strain on the shoulder complex [2,36]. The studies included in this review consistently reported that athletes experienced decreased pain levels following structured exercise programs, particularly those focusing on scapular stabilization and neuromuscular control [5,14,15,17,30,32,33]. For instance, Wen et al. (2025) demonstrated that participants in the Scapular Dyskinesis-Based Exercise Therapy group-maintained pain reduction at the 12-week follow-up, indicating the long-term benefits of such interventions [5]. This sustained improvement in pain levels suggests that movement-based exercises not only provide immediate relief but also contribute to lasting changes in shoulder function and mechanics. The ability to maintain reduced pain levels over time is crucial for athletes, as it allows them to engage in training and competition without the fear of exacerbating their condition [37]. The mechanisms underlying pain reduction in athletes undergoing movement-based exercises may be multifaceted [38,39]. First, these exercises often emphasize proper scapular positioning and movement patterns, which can help restore normal biomechanics and reduce the strain on the shoulder joint [5]. By improving scapular stability and coordination, athletes may experience less discomfort during overhead activities, leading to enhanced performance and reduced disability [36]. Additionally, the incorporation of neuromuscular training may enhance proprioception and motor control, further contributing to pain alleviation by promoting more efficient movement strategies [40,41]. Moreover, the psychological aspects of pain management should not be overlooked. Engaging in a structured exercise program can empower athletes, providing them with a sense of control over their recovery process. This empowerment can lead to improved mental well-being and a reduction in pain perception, as athletes may feel more confident in their ability to manage their condition. The positive feedback loop created by pain reduction and improved function can significantly enhance an athlete's overall quality of life [42,43].

This aligns with previous literature suggesting that targeted rehabilitation can effectively alleviate pain and improve quality of life in individuals with shoulder dysfunction [44,45]. Studies have shown that exercise interventions focusing on scapular dyskinesis can lead to significant improvements in pain intensity [30,32]. Furthermore, the reduction in pain is often accompanied by improvements in functional outcomes, such as increased ROM and enhanced strength, which collectively contribute to an athlete's ability to perform at their best [5]. In summary, the evidence from this review underscores the effectiveness of movement-based exercises in reducing pain and disability among athletes with scapular dyskinesis. By addressing the underlying biomechanical issues and promoting proper movement patterns, these interventions not only alleviate pain but also enhance overall shoulder function, allowing athletes to return to their sport with greater confidence and reduced risk of re-injury.

4.2. Improvements in ROM and Muscle Strength

The review also highlighted notable improvements in ROM and muscle strength among athletes undergoing movement-based exercises. Enhanced ROM is critical for athletes, particularly in overhead sports, where shoulder mobility is essential for optimal performance [46,47]. Limitations in shoulder ROM can significantly hinder an athlete's ability to execute skills effectively, such as throwing, serving, or spiking, which require a full ROM for maximal power and precision [48–50]. Studies such as those by Naderifar and Ghanbari (2022) and Khakpourfard et al. (2023) reported significant gains in both internal and external rotation [12,35]. For instance, Naderifar and Ghanbari (2022) demonstrated that participants in their study experienced marked improvements in glenohumeral internal rotation following a structured exercise program. This increase in internal rotation is particularly important for athletes involved in sports that require overhead motions, as it allows for more effective arm positioning and force generation during performance [12,35]. Furthermore, the increase in muscle strength, particularly in the rotator cuff and scapular stabilizers, supports the notion that stabilization exercises can restore normal scapular mechanics and improve overall shoulder function [51,52]. The rotator cuff muscles play a crucial role in stabilizing the

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glenohumeral joint during dynamic movements, and their strength is essential for maintaining proper shoulder mechanics [53,54]. Studies have shown that different interventions can lead to significant improvements in the strength of these muscles, which in turn enhances the stability of the shoulder joint and reduces the risk of injury [55–57]. Additionally, the improvements in muscle strength observed in the included studies were not limited to the rotator cuff; athletes also demonstrated enhanced strength in the scapular stabilizers, such as the serratus anterior and trapezius muscles [58]. These muscles are vital for maintaining proper scapular positioning during arm movements, and their strengthening can lead to improved scapular kinematics [58,59]. As a result, athletes may experience not only enhanced performance but also a reduced likelihood of developing shoulder-related injuries [60].

In summary, the evidence from this review underscores the importance of movement-based exercises in improving both ROM and muscle strength among athletes with scapular dyskinesis. By addressing these critical components, rehabilitation programs can facilitate better shoulder function, ultimately contributing to enhanced athletic performance and reduced injury risk.

4.3. Scapular Kinematics and Functionality

The findings regarding scapular kinematics are particularly noteworthy, as they highlight the critical role of proper scapular mechanics in shoulder function and overall athletic performance [61]. Several studies indicated that movement-based exercises led to improved scapulohumeral rhythm and reduced scapular dyskinesis [13,31]. Scapulohumeral rhythm refers to the coordinated movement of the scapula and humerus during shoulder motion, which is essential for maintaining optimal shoulder mechanics [62]. Disruptions in this rhythm can lead to compensatory movement patterns, increased strain on the shoulder joint, and a heightened risk of injury [63]. The improvements in scapular kinematics observed in studies like those by Gholamian et al. (2024) suggest that targeted interventions can enhance neuromuscular control and coordination, which are often compromised in athletes with dyskinesis [13]. By focusing on exercises that promote proper scapular positioning and movement, athletes can develop better motor control, leading to more efficient and effective shoulder function [64,65]. For instance, Gholamian et al. (2024) reported significant enhancements in scapulohumeral rhythm following a functional training program, indicating that structured exercise can facilitate the restoration of normal scapular mechanics [13]. Moreover, the benefits of improved scapular kinematics extend beyond immediate performance enhancements. Proper scapular mechanics are crucial for injury prevention, particularly in overhead athletes who are susceptible to shoulder injuries [36,66]. By addressing scapular dyskinesis through movement-based exercises, athletes can reduce the likelihood of developing conditions such as rotator cuff tears, shoulder impingement, and other overuse injuries [9]. The restoration of normal scapular function not only contributes to improved athletic performance but also promotes long-term shoulder health [67,68].

In summary, the evidence from this review underscores the importance of movement-based exercises in improving scapular kinematics and functionality. By enhancing scapulohumeral rhythm and reducing dyskinesis, these interventions can lead to better neuromuscular control, improved shoulder mechanics, and ultimately, a lower risk of injury for athletes. This highlights the need for incorporating targeted rehabilitation strategies into training regimens for athletes with scapular dyskinesis.

4.4. Limitations and Future Directions

Despite the promising findings, this review is not without limitations. The heterogeneity of the included studies in terms of sample size, intervention protocols, and outcome measures makes it challenging to draw definitive conclusions. Additionally, the quality of the studies varied, with some exhibiting a higher risk of bias, particularly among non-randomized controlled trials. Future research should aim to standardize intervention protocols and utilize larger sample sizes to enhance the generalizability of the findings. Longitudinal studies are also needed to assess the long-term effects of movement-based exercises on sports performance and injury prevention.

4.5. Clinical Implications

The implications of this review are significant for clinicians and sports professionals. The evidence supports the integration of movement-based exercises into rehabilitation programs for athletes with scapular dyskinesis. By focusing on improving scapular stability, strength, and coordination, practitioners can enhance athletic performance and reduce the likelihood of shoulder injuries. Furthermore, the findings emphasize the need for individualized rehabilitation programs that consider the specific needs and characteristics of each athlete.

5. Conclusions

In conclusion, this systematic review provides compelling evidence that movement-based exercises can positively impact sports performance in athletes with scapular dyskinesis. The improvements in pain, ROM, muscle strength, and scapular kinematics highlight the importance of targeted rehabilitation strategies. As the understanding of scapular dyskinesis continues to evolve, further research is essential to refine intervention approaches and optimize outcomes for athletes. By prioritizing effective rehabilitation, we can support athletes in achieving their performance goals while minimizing the risk of injury.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, File S1: title; File S2: title.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, H.K., M.ALI., H.D. and M.ALG.; methodology, H.K., N.N., Y.D.; software, M.ALG. and M.ALI.; validation, H.K., N.N., Y.D.; formal analysis, H.K. and M.ALI.; investigation, Y.D. and B.S.; resources, M.S.-T. and H.D.; data curation, H.K. and M.ALI.; writing—original draft preparation, H.K., M.ALI., N.N., Y.D., B.S., M.ALG., H.D.; writing—review and editing, M. ALI., M.ALG. and M.S.-T.; visualization, H.K. and N.N.; supervision, M.S.-T. and H.D.; project administration, M.S.-T. All authors have read and agreed to the published version of the manuscript.

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Abbreviations

The following abbreviations are used in this manuscript:

ROM	Range of Motion
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
PICOS	Population, Intervention, Comparison, Outcome, and Study design
ROBINS-I	Risk Of Bias In Non-randomized Studies - of Interventions

RCT	Randomized Controlled Trial
RoB-2	Risk of Bias 2 (tool)
SWiM	Synthesis Without Meta-Analysis

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