

Effects of Scapular Dyskinesia on Overhead Athletes' Shoulder Pain and Function: A Review

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ABSTRACT

Background: Scapular dyskinesia is an alteration in scapular position or motion that may disturb scapulohumeral rhythm, reduce dynamic shoulder stability, and impair force transmission during overhead activity. Because overhead athletes repeatedly expose the shoulder complex to high-velocity and high-volume loading, altered scapular control may contribute to shoulder pain, functional limitation, performance decline, and injury susceptibility. **Objective:** This systematic review aimed to synthesize recent evidence on the effects of scapular dyskinesia on shoulder pain, shoulder function, biomechanics, athletic performance, rehabilitation response, and injury risk in overhead athletes. **Methods:** A structured literature search was conducted using PubMed and Google Scholar for studies published between 2020 and 2025. Search terms included scapular dyskinesia, scapular kinematics, scapulohumeral rhythm, shoulder pain, shoulder function, overhead athletes, rotator cuff, subacromial impingement, sports injury, biomechanics, neuromuscular control, and rehabilitation. Eligible studies included randomized controlled trials, cohort studies, cross-sectional studies, systematic reviews, and meta-analyses involving adult overhead athletes or physically active adults in whom scapular dyskinesia was assessed in relation to pain, function, biomechanics, performance, injury risk, or rehabilitation outcomes. Findings were synthesized qualitatively because of heterogeneity in study design, populations, assessment methods, and outcome measures. **Results:** The included evidence showed that scapular dyskinesia is common in overhead athletes and is associated with altered scapular kinematics, abnormal activation of scapular stabilizers, impaired neuromuscular control, reduced shoulder strength and endurance, and decreased functional performance. Dyskinesia was also associated with shoulder pain, particularly in rotator cuff-related and subacromial impingement-related conditions; however, its presence in asymptomatic athletes indicates that it should not be interpreted as pathological in isolation. Scapular-focused rehabilitation, including stabilization exercise, neuromuscular control training, and sport-specific movement retraining, was generally associated with improved pain, function, and movement quality. **Conclusion:** Scapular dyskinesia is a clinically relevant but context-dependent contributor to shoulder pain and dysfunction in overhead athletes. Comprehensive assessment and individualized rehabilitation targeting scapular control, muscular balance, load management, and sport-specific reintegration may improve functional outcomes and support safer return to overhead activity. **Keywords:** Scapular Dyskinesia; Shoulder Pain; Shoulder Function; Overhead Athletes; Scapular Kinematics; Rehabilitation; Rotator Cuff; Sports Injuries.

INTRODUCTION

Scapular dyskinesia refers to an observable alteration in the resting position or dynamic motion of the scapula during shoulder movement, commonly involving excessive anterior tilting, internal rotation, reduced upward rotation, or impaired coordinated control of scapulohumeral rhythm (1). In overhead

athletes, the scapula provides the stable yet mobile base required for efficient glenohumeral motion, force transmission, kinetic-chain integration, and maintenance of subacromial space during high-demand sporting activities such as throwing, serving, spiking, and swimming (2). When scapular motion becomes poorly controlled, the shoulder complex may be exposed to altered loading patterns, reduced muscular efficiency, impaired proprioception, and increased mechanical stress on the rotator cuff, bursa, labrum, and surrounding soft tissues (3).

Shoulder pain and functional limitation are common problems in athletes who repeatedly perform overhead movements, and even small disturbances in scapular control may become clinically meaningful when repeated under high velocity, fatigue, and sport-specific load. Previous biomechanical and clinical studies have suggested that scapular dyskinesis is frequently observed in athletes with shoulder disorders and may be associated with reduced strength, altered neuromuscular activation, decreased endurance, impaired accuracy, and reduced sport performance (4,5). In particular, abnormal activation of the serratus anterior and trapezius muscle groups may compromise dynamic scapular stability, thereby disrupting the normal scapulohumeral rhythm required for pain-free elevation and efficient overhead activity (6).

Despite growing interest in scapular dyskinesis, its clinical interpretation remains complex. Some athletes with visible scapular dyskinesis remain asymptomatic, suggesting that altered scapular motion may sometimes represent adaptation rather than pathology. Conversely, longitudinal and rehabilitation-based evidence indicates that dyskinesis may contribute to shoulder pain, dysfunction, or future injury risk in selected athletic populations, particularly when accompanied by fatigue, muscle imbalance, reduced neuromuscular control, or high repetitive load (7,8). This distinction is important because overdiagnosis may lead to unnecessary treatment, whereas under-recognition may delay targeted rehabilitation in athletes at risk of persistent symptoms or performance decline.

Existing literature has examined scapular dyskinesis in relation to shoulder biomechanics, pain, function, injury risk, and rehabilitation outcomes; however, findings remain heterogeneous because of variation in athlete populations, assessment techniques, sport types, outcome measures, and study designs. Some studies use clinical observation methods such as the Scapular Dyskinesis Test, whereas others rely on instrument-based kinematic analysis, making direct comparison difficult. Similarly, shoulder outcomes have been assessed using pain scales, disability questionnaires, performance-based tests, electromyographic measures, and sport-specific functional outcomes, which limits the ability to draw uniform conclusions across studies (9,10). Therefore, an updated synthesis is needed to clarify how recent evidence characterizes the relationship between scapular dyskinesis, shoulder pain, functional impairment, performance, and injury risk in overhead athletes.

Using a PICO framework, the population of interest in this review is adult overhead athletes or physically active adults involved in overhead sporting activity; the exposure is scapular dyskinesis or altered scapular kinematics; the comparator is normal scapular motion, absence of dyskinesis, or pre-intervention status where applicable; and the outcomes of interest are shoulder pain, shoulder function, biomechanics, athletic performance, rehabilitation response, and injury risk. Accordingly, this review aims to synthesize recent evidence on the effects of scapular dyskinesis on shoulder pain and function in overhead athletes and to examine its implications for clinical assessment, rehabilitation, performance, and injury prevention.

MATERIALS AND METHODS

This systematic review was designed to synthesize recent evidence on the association between scapular dyskinesis and shoulder pain, shoulder function, biomechanics, athletic performance, rehabilitation response, and injury risk in overhead athletes. The review was conducted in accordance with PRISMA 2020 principles to support transparent identification, selection, appraisal, and synthesis of evidence (11).

A structured literature search was conducted using PubMed and Google Scholar to identify relevant studies published from 2020 to 2025. The search strategy combined controlled vocabulary and free-text terms related to scapular motion, shoulder symptoms, athletic populations, and rehabilitation. Key terms included “scapular dyskinesis,” “scapular kinematics,” “scapulohumeral rhythm,” “shoulder pain,” “shoulder function,” “overhead athletes,” “throwing athletes,” “swimmers,” “volleyball players,” “baseball players,” “rotator cuff,” “subacromial impingement,” “sports injury,” “biomechanics,” “neuromuscular control,” and “rehabilitation.” Boolean operators were used to combine terms, including combinations such as “scapular dyskinesis” AND “overhead athletes,” “scapular kinematics” AND “shoulder pain,” and “scapular stabilization” AND “shoulder function.”

Studies were considered eligible if they included adult overhead athletes or physically active adults aged 18 years or older and evaluated scapular dyskinesis or altered scapular kinematics in relation to shoulder pain, function, biomechanics, performance, injury risk, or rehabilitation outcomes. Eligible study designs included randomized controlled trials, cohort studies, cross-sectional studies, systematic reviews, and meta-analyses. Studies were included when they assessed scapular dyskinesis using clinical observation methods, validated functional assessments, electromyographic evaluation, or instrument-based kinematic analysis, and when they reported outcomes related to pain intensity, disability, functional performance, muscle activation, scapular positioning, injury occurrence, or response to scapular-focused intervention.

Studies were excluded if they were published before the defined search period, involved non-athletic populations without specific relevance to overhead activity, focused on unrelated neurological or musculoskeletal disorders, or were case reports, editorials, letters, conference abstracts, animal studies, or non-peer-reviewed commentaries. Studies were also excluded when scapular dyskinesis was not assessed as a central exposure, clinical feature, biomechanical factor, or rehabilitation target.

After removal of duplicates, titles and abstracts were screened for relevance according to the eligibility criteria. Full-text articles were then assessed to determine final inclusion. During full-text assessment, priority was given to studies that directly examined the relationship between scapular dyskinesis and shoulder pain, function, biomechanics, performance, or injury risk in overhead athletes. Studies evaluating scapular-focused rehabilitation were included when outcomes were relevant to pain reduction, functional improvement, neuromuscular control, or restoration of scapular mechanics.

Data were extracted using a structured approach. Extracted variables included author name, year of publication, country, study design, sample size, participant characteristics, sport type, age group, scapular dyskinesis assessment method, shoulder pain and function outcome measures, biomechanical or electromyographic variables, intervention characteristics where applicable, follow-up duration, and principal findings relevant to the review objective. Shoulder pain and function outcomes included measures such as visual analogue scale scores, disability indices, shoulder-specific functional questionnaires, range of motion, strength, endurance, proprioception, and sport-specific performance measures.

Methodological quality was assessed according to study design. Randomized controlled trials were evaluated with attention to allocation procedures, intervention description, comparability of groups, outcome measurement, follow-up completeness, and reporting of between-group effects. Observational studies were assessed for clarity of population definition, exposure measurement, outcome validity, control of confounding, sample adequacy, and appropriateness of statistical analysis. Systematic reviews and meta-analyses were assessed for clarity of eligibility criteria, search strategy, study selection process, quality appraisal, synthesis method, and transparency of conclusions.

Because the included literature differed in study design, athlete population, sport type, scapular assessment method, outcome measure, and intervention approach, a meta-analysis was not performed. Findings were synthesized narratively and organized according to clinically relevant outcome domains:

prevalence and clinical presentation of scapular dyskinesia, biomechanical and neuromuscular alterations, association with shoulder pain, effect on shoulder function and sport performance, relationship with future injury risk, and response to scapular-focused rehabilitation. The direction and consistency of evidence were interpreted across study designs while distinguishing observational associations from interventional findings.

RESULTS

The evidence synthesis included recent literature addressing scapular dyskinesia in relation to shoulder biomechanics, neuromuscular control, pain, function, athletic performance, injury risk, and rehabilitation outcomes in overhead athletes and physically active adults. The included evidence comprised systematic reviews, meta-analyses, randomized clinical trials, cohort studies, cross-sectional studies, and biomechanical investigations published mainly between 2020 and 2026.

Table 1. Characteristics of Included Evidence

Study / Evidence Source	Year	Design	Population / Context	Main Focus	Key Findings Relevant to Review
Longo et al.	2020	Basic science / clinical review	Individuals with scapular dyskinesia and shoulder dysfunction	Mechanisms and treatment principles	Described scapular dyskinesia as a multifactorial condition involving altered kinematics, muscle imbalance, and impaired shoulder mechanics.
Goetti et al.	2020	Biomechanical review	Normal and pathological shoulder conditions	Shoulder biomechanics	Highlighted the role of scapular positioning and coordinated shoulder mechanics in maintaining functional shoulder movement.
Paraskevopoulos et al.	2020	Systematic review	Asymptomatic subjects	Reliability of scapular dyskinesia assessment	Reported variability in assessment methods, emphasizing the need for standardized clinical evaluation.
Hogan et al.	2021	Systematic review and meta-analysis	Athletes	Shoulder injury risk	Found that scapular dyskinesia alone should not be interpreted as an isolated predictor of shoulder injury.
Sayaca et al.	2021	Observational clinical study	Post-Bankart repair patients	Joint position sense and function	Linked scapular dyskinesia with altered proprioception and functional level after shoulder stabilization procedures.
Khodaverdizadeh et al.	2023	Systematic review and meta-analysis	People with scapular dyskinesia	Scapular-focused exercise therapy	Reported beneficial effects of scapular-focused exercise on shoulder pain, function, and scapular positioning.
Longo et al.	2023	Prospective cohort study	Patients with rotator cuff tears	Scapular kinematics	Demonstrated altered scapular motion patterns in rotator cuff pathology.
Kibler et al.	2024	Biomechanical / clinical review	Throwing athletes	Shoulder joint complex during throwing	Emphasized scapular contribution to kinetic-chain function during throwing motion.
Tang et al.	2024	Randomized clinical trial	Patients with shoulder pain	Targeted scapular stabilization	Found targeted scapular stabilization superior to conventional exercise for improving shoulder outcomes.
de Paula Marques and Dionisio	2024	Systematic review	Overhead athletes	Electromyographic findings	Identified abnormal activation patterns of scapular stabilizers in overhead athletes with dyskinesia.
Fernández-Matías et al.	2025	Systematic review with meta-regression	Individuals with and without rotator cuff-related shoulder pain	Scapular kinematics variability	Reported differences in scapular kinematic variability between painful and non-painful shoulder groups.
Rudraswamy et al.	2025	Correlational study	Shoulder pain conditions	Dyskinesia and pain correlation	Supported an association between scapular dyskinesia and shoulder pain conditions.
Wen, Hu and Bao	2025	Randomized controlled trial	Young overhead athletes with subacromial impingement and scapular dyskinesia	Scapular dyskinesia-based exercise therapy	Showed improvement in pain and function following scapular-focused exercise therapy.
Joo and Kim	2025	Cross-sectional study	Adult elite swimmers	Associated factors	Reported scapular dyskinesia as common in elite swimmers and linked with sport-specific shoulder demands.
Toledo et al.	2025	Prospective cohort study	Volleyball athletes	Shoulder pain, injury, and dysfunction risk	Examined scapular and sport-related risk factors for shoulder symptoms in volleyball athletes.
Paksoy et al.	2025	Cross-sectional study	Professional basketball players	Asymptomatic dyskinesia	Found scapular dyskinesia to be common even among asymptomatic professional athletes.
Solana-Tramunt et al.	2026	Systematic review	Athletes with scapular dyskinesia	Scapular-focused movement-based exercise	Reported performance-related benefits of scapular-focused exercise approaches.

The included evidence showed that scapular dyskinesia is common in overhead athletes and in individuals with shoulder pain conditions. Across the evidence base, dyskinesia was most frequently

described as altered scapular positioning or movement during arm elevation, especially involving reduced upward rotation, increased anterior tilt, internal rotation, and disturbed scapulohumeral rhythm. These alterations were repeatedly linked with impaired force transmission, reduced dynamic shoulder stability, and inefficient movement during repetitive overhead activity.

Biomechanical findings consistently indicated that the scapula plays a central role in maintaining shoulder efficiency during overhead motion. When scapular motion is altered, the shoulder may lose optimal glenohumeral alignment, subacromial space may be reduced, and the rotator cuff and surrounding soft tissues may experience greater mechanical demand. This pattern was particularly relevant in sports requiring repeated high-velocity or high-volume overhead movement, including throwing, swimming, serving, and spiking.

Table 2. Evidence Synthesis by Outcome Domain

Outcome Domain	Direction of Evidence	Main Findings	Clinical Interpretation
Prevalence / clinical presentation	Consistently reported as common in athletic and shoulder pain populations	Scapular dyskinesia appeared frequently in overhead athletes, swimmers, volleyball players, basketball players, and individuals with shoulder disorders.	Dyskinesia is clinically relevant but should not be treated as pathological in every athlete because it may also appear in asymptomatic populations.
Biomechanics	Consistent evidence of altered scapular mechanics	Reduced upward rotation, increased anterior tilt, internal rotation, altered scapulohumeral rhythm, and reduced dynamic stability were repeatedly described.	Altered scapular mechanics may reduce subacromial space, impair force transfer, and increase tissue loading during overhead movement.
Neuromuscular control	Consistent evidence of altered stabilizer activation	Abnormal activation of the serratus anterior, upper trapezius, and lower trapezius was reported during overhead activity.	Impaired neuromuscular control may contribute to inefficient shoulder motion, early fatigue, and reduced movement quality.
Shoulder pain	Moderate evidence of association	Dyskinesia was associated with shoulder pain, particularly in athletes exposed to repetitive overhead loading and in rotator cuff-related or impingement-related conditions.	Pain should be interpreted as part of a broader movement-control problem rather than only as a local tissue symptom.
Shoulder function	Moderate to strong evidence of impairment	Reduced strength, endurance, range of motion, coordination, proprioception, and functional performance were reported in athletes with dyskinesia.	Functional assessment should include scapular control, kinetic-chain contribution, sport-specific tasks, and symptom response.
Athletic performance	Emerging evidence of negative impact	Reduced throwing efficiency, accuracy, endurance, swimming-related shoulder control, and sport-specific performance were described.	Performance impairment may result from inefficient force transmission and fatigue-related loss of scapular control.
Injury risk	Mixed evidence	Some prospective evidence linked dyskinesia with future shoulder symptoms, while meta-analytic evidence indicated that dyskinesia alone is not an isolated risk factor.	Dyskinesia should be considered one component of a multifactorial injury-risk profile rather than a stand-alone predictor.
Rehabilitation response	Consistently favorable across intervention evidence	Scapular stabilization, neuromuscular control training, and movement-based exercise improved pain, function, and scapular mechanics.	Rehabilitation should target motor control, muscle balance, endurance, and sport-specific reintegration.

Table 3. Sport- and Population-Specific Findings

Population / Sport Context	Scapular Dyskinesia Pattern	Associated Shoulder Outcome	Key Findings
Overhead athletes broadly	Altered scapular positioning and impaired scapulohumeral rhythm	Shoulder pain, functional limitation, reduced performance, and injury susceptibility	Repetitive overhead loading increases the clinical relevance of scapular control deficits.
Throwing athletes	Reduced scapular control during high-velocity kinetic-chain movement	Reduced throwing efficiency, impaired force transfer, and increased shoulder stress	The scapula acts as a key link between trunk-generated force and upper-limb acceleration.
Swimmers	Dyskinesia associated with repeated cyclic overhead loading	Shoulder pain risk, fatigue, and altered stabilizer control	High training volume may expose endurance-related deficits in scapular stabilizers.
Volleyball athletes	Dyskinesia considered among risk factors for shoulder symptoms	Shoulder pain, dysfunction, and performance limitation	Repetitive spiking and serving may increase load on the scapular stabilizer system.
Basketball athletes	Dyskinesia observed even without symptoms	Often asymptomatic despite altered scapular motion	Presence of dyskinesia alone does not confirm pathology and requires clinical correlation.
Rotator cuff-related shoulder pain populations	Altered scapular variability and kinematics	Pain, disability, reduced function	Dyskinesia may interact with rotator cuff loading and subacromial mechanics.
Subacromial impingement populations	Altered scapular motion and reduced control	Painful overhead movement and functional disability	Scapular-focused exercise may reduce symptoms by improving movement mechanics.

Neuromuscular findings suggested that scapular dyskinesia is not only a positional abnormality but also a motor-control problem. Abnormal activation of key scapular stabilizers, particularly the serratus

anterior and trapezius muscle groups, was repeatedly described in overhead athletes with dyskinesia. Reduced coordination of these muscles may impair scapular upward rotation, posterior tilt, and external rotation during arm elevation. This mechanism provides a plausible explanation for reduced shoulder endurance, early fatigue, and loss of movement precision during sport-specific tasks.

Table 4. Rehabilitation-Oriented Evidence

Intervention Focus	Targeted Impairment	Reported Effect	Practical Meaning
Scapular stabilization exercise	Reduced scapular control and altered positioning	Improved pain and shoulder function	Supports inclusion of scapular control exercises in rehabilitation plans.
Serratus anterior activation	Reduced upward rotation and posterior tilt control	Improved scapular movement efficiency	Important for restoring dynamic scapular stability during arm elevation.
Lower trapezius strengthening	Excessive upper trapezius dominance and poor scapular depression/retraction control	Improved scapular coordination	Helps rebalance scapular force couples during overhead activity.
Neuromuscular control training	Poor motor control and proprioceptive deficits	Improved movement quality and functional performance	Particularly relevant for athletes returning to high-speed sport-specific movement.
Movement-based scapular exercise	Deficient sport-specific control	Improved functional and performance-related outcomes	Rehabilitation should progress from isolated activation to integrated athletic tasks.
Load and fatigue management	Fatigue-related deterioration of scapular mechanics	Reduced symptom provocation and improved tolerance	Training volume and recovery should be considered part of shoulder rehabilitation.
Conventional exercise alone	General strengthening without specific scapular emphasis	Less targeted improvement in scapular mechanics	General shoulder exercise may be insufficient when dyskinesia is a prominent clinical feature.

Table 5. Summary of Evidence Strength and Main Gaps

Evidence Area	Strength of Evidence	Main Limitations Observed Across Evidence	Key Findings
Association with shoulder pain	Moderate	Heterogeneous populations, variable pain measures, mixed study designs	Dyskinesia is associated with pain but is not always causal.
Effect on shoulder function	Moderate to strong	Different functional scales and performance tests across studies	Functional limitation is a clinically important outcome in athletes with dyskinesia.
Biomechanical alteration	Strong	Variation in clinical and instrument-based assessment methods	Altered scapular kinematics are central to the dyskinesia construct.
Neuromuscular impairment	Moderate	EMG protocols and movement tasks differ between studies	Altered stabilizer activation supports a motor-control-based rehabilitation approach.
Injury prediction	Low to moderate	Dyskinesia often interacts with other risk factors	Dyskinesia should be assessed as part of a multifactorial risk model.
Rehabilitation effectiveness	Moderate	Intervention protocols, duration, and follow-up vary	Scapular-focused rehabilitation appears beneficial for pain and function.
Sport-specific performance	Emerging	Fewer studies use direct sport-performance outcomes	More evidence supports functional improvement than direct performance enhancement.

Evidence relating scapular dyskinesia to shoulder pain was generally supportive but not uniformly causal. Several studies associated dyskinesia with shoulder pain conditions such as rotator cuff-related shoulder pain and subacromial impingement-related symptoms. However, dyskinesia was also reported in asymptomatic professional athletes, indicating that visible scapular alteration does not automatically indicate pathology. The results therefore support a clinically balanced interpretation: scapular dyskinesia is relevant when it occurs alongside pain, weakness, fatigue, reduced function, or impaired sport performance, but it should not be interpreted in isolation.

Shoulder function was consistently affected across the evidence domains. Athletes with scapular dyskinesia commonly showed reduced strength, endurance, coordination, proprioception, and functional performance during overhead movement. These functional deficits are clinically important because overhead sports depend on repeated, coordinated transfer of force from the trunk and lower limb through the scapula and shoulder to the arm. Even modest impairment in scapular control may become meaningful when repeated under competitive load, fatigue, or high training volume.

The evidence on athletic performance suggested that scapular dyskinesia may reduce sport-specific efficiency. In throwing athletes, altered scapular control may impair kinetic-chain transfer and reduce throwing quality. In swimmers, repeated cyclic overhead loading may expose endurance-related scapular stabilizer fatigue. In volleyball players, repeated serving and spiking may increase the demand on scapular control and contribute to shoulder symptoms. In basketball players, the presence of dyskinesia

among asymptomatic professionals showed that sport adaptation and pathology must be differentiated carefully.

The relationship between scapular dyskinesis and future injury risk was mixed. Some prospective evidence suggested that athletes with scapular abnormalities may be more likely to develop shoulder symptoms over time. However, broader evidence indicated that dyskinesis alone should not be treated as an isolated injury-risk factor. The findings support a multifactorial model in which dyskinesis interacts with workload, fatigue, strength deficits, previous injury, rotator cuff function, sport demands, and kinetic-chain control.

Rehabilitation evidence was more consistent. Scapular-focused interventions, including stabilization exercise, serratus anterior and lower trapezius strengthening, neuromuscular control training, and movement-based rehabilitation, were associated with improvements in pain, shoulder function, scapular positioning, and sport-related movement quality. The strongest clinical implication from the synthesis is that rehabilitation should not focus only on local shoulder strengthening; it should also restore scapular motor control, endurance, muscular balance, and sport-specific integration.

Overall, the synthesis indicates that scapular dyskinesis is a clinically meaningful but context-dependent finding in overhead athletes. Its importance is greatest when altered scapular mechanics coexist with pain, impaired neuromuscular control, reduced function, fatigue, or declining performance. The evidence supports routine scapular assessment as part of a broader shoulder evaluation and favors rehabilitation strategies that combine scapular stabilization, neuromuscular retraining, load management, and progressive return to overhead activity.

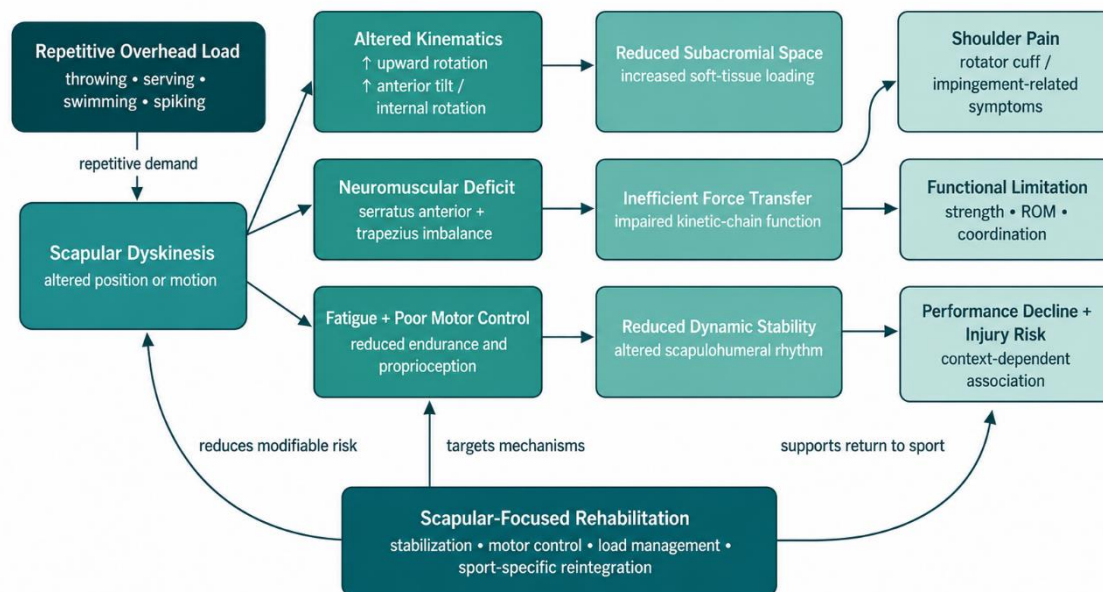


Figure 1. Mechanistic Pathway Linking Scapular Dyskinesis with Shoulder Outcomes in Overhead Athletes

The figure presents a conceptual synthesis of the review evidence, showing how repetitive overhead loading may contribute to scapular dyskinesis through altered scapular kinematics, neuromuscular imbalance, fatigue, and poor motor control. These mechanisms are linked to reduced subacromial space, inefficient kinetic-chain force transfer, and reduced dynamic shoulder stability, which may contribute to shoulder pain, functional limitation, performance decline, and context-dependent injury risk. The model also highlights scapular-focused rehabilitation as a modifying pathway targeting stabilization, neuromuscular control, load management, and sport-specific reintegration. This figure is derived from the qualitative synthesis and does not include fabricated numerical values or pooled effect estimates.

DISCUSSION

This review synthesized recent evidence on the relationship between scapular dyskinesis and shoulder pain, function, biomechanics, performance, injury risk, and rehabilitation outcomes in overhead athletes. The principal finding is that scapular dyskinesis is best understood as a context-dependent movement-control impairment rather than a single isolated structural abnormality. Across the included evidence, dyskinesis was repeatedly associated with altered scapular kinematics, impaired scapulohumeral rhythm, abnormal activation of scapular stabilizers, reduced shoulder efficiency, and functional limitations during overhead activity. These findings align with the stated objective by showing that scapular dyskinesis may influence shoulder symptoms and performance through both biomechanical and neuromuscular pathways.

A consistent theme across the evidence is the biomechanical importance of the scapula as a mobile base for glenohumeral function. During overhead sport, the scapula must upwardly rotate, posteriorly tilt, and externally rotate in a coordinated manner to maintain subacromial space, optimize rotator cuff function, and support efficient transfer of force through the kinetic chain. When scapular motion is altered, particularly through reduced upward rotation, increased anterior tilting, or excessive internal rotation, the shoulder may experience less efficient force coupling and greater mechanical demand on the rotator cuff, subacromial tissues, and labral structures (12,13). This provides a plausible mechanism linking dyskinesis with shoulder pain and dysfunction, especially in athletes exposed to repeated high-velocity or high-volume overhead loading.

The neuromuscular findings further suggest that scapular dyskinesis should not be interpreted only as a visible positional abnormality. Altered activation of the serratus anterior, upper trapezius, and lower trapezius indicates that dyskinesis often reflects impaired motor control, fatigue resistance, and muscular coordination. In overhead athletes, these deficits may become more clinically important during sport-specific movements above 90° of elevation, where precise scapular control is required to preserve shoulder stability and movement efficiency. This supports the view that assessment should extend beyond static observation and include dynamic movement analysis, fatigue response, strength, endurance, proprioception, and sport-specific task performance (14).

The relationship between scapular dyskinesis and shoulder pain appears clinically important but not uniformly causal. Several studies included in the synthesis associated dyskinesis with painful shoulder conditions such as rotator cuff-related shoulder pain and subacromial impingement-related symptoms (15). However, the presence of scapular dyskinesis in asymptomatic athletes indicates that altered scapular motion does not always represent pathology. This distinction is essential for clinical interpretation: dyskinesis should be considered meaningful when it occurs together with pain, weakness, fatigue, impaired function, loss of performance, or previous injury, rather than being treated as an independent diagnosis in every athlete (16).

The evidence on injury risk also supports a multifactorial interpretation. Some prospective and cohort findings suggest that athletes with observable scapular abnormalities may have greater likelihood of developing shoulder symptoms over time, but broader evidence indicates that scapular dyskinesis alone should not be viewed as an isolated predictor of injury (17). Injury risk in overhead athletes is more likely shaped by the interaction of scapular control, training load, fatigue, rotator cuff capacity, kinetic-chain mechanics, previous injury history, sport-specific demand, and recovery practices. Therefore, dyskinesis may be better understood as one modifiable component within a broader risk profile rather than a stand-alone screening marker.

The rehabilitation findings provide one of the most clinically useful outcomes of this synthesis. Scapular-focused interventions, including stabilization exercises, serratus anterior and lower trapezius strengthening, neuromuscular control training, and progressive sport-specific movement retraining, were associated with improvements in pain, function, scapular mechanics, and performance-related

outcomes. This supports rehabilitation models that move beyond general shoulder strengthening and specifically target scapular control, muscular balance, endurance, and kinetic-chain integration (18,19). In practical terms, effective rehabilitation should progress from isolated activation and motor-control drills to loaded, fatigued, and sport-specific overhead tasks that reflect the athlete's competitive demands.

These findings are broadly consistent with the wider shoulder rehabilitation literature, which emphasizes the role of coordinated scapular and glenohumeral motion in maintaining shoulder health. The review also advances the field by emphasizing that scapular dyskinesis should be interpreted according to clinical context. Rather than assuming that every visible scapular alteration requires correction, clinicians should determine whether the observed movement pattern is associated with symptoms, impaired function, reduced performance, or modifiable deficits. This approach may reduce overdiagnosis while still identifying athletes who are likely to benefit from targeted rehabilitation.

The review has several methodological limitations that should be considered when interpreting the findings. The included studies varied substantially in design, population, sport type, assessment method, outcome measure, and intervention protocol. Clinical observation tests, electromyographic analysis, kinematic assessment, pain scales, disability questionnaires, and sport-specific performance measures were not applied uniformly across studies, limiting direct comparison. In addition, the absence of quantitative pooling means that the magnitude of association between scapular dyskinesis and pain, function, or injury risk could not be estimated statistically. The evidence base also included both symptomatic and asymptomatic athletes, which strengthens clinical relevance but increases heterogeneity.

Another limitation is that many included findings are observational, making causal interpretation difficult. Cross-sectional associations between dyskinesis and shoulder pain cannot determine whether altered scapular motion causes symptoms, results from symptoms, or reflects compensation. Prospective studies are more informative for injury prediction, but the current evidence suggests that dyskinesis interacts with multiple risk factors rather than acting independently. Similarly, intervention studies support the value of scapular-focused rehabilitation, but protocols differ in exercise content, duration, intensity, progression, and outcome timing. This variability limits the ability to identify one optimal rehabilitation approach.

The clinical implications are clear. Assessment of overhead athletes with shoulder pain should include scapular motion, muscle activation patterns, strength, endurance, fatigue response, kinetic-chain contribution, and sport-specific movement quality. Rehabilitation should be individualized according to the athlete's deficits and sport demands, with attention to load management and progressive return to overhead activity (20). For asymptomatic athletes, scapular dyskinesis should be interpreted cautiously and monitored in relation to workload, fatigue, previous injury, and performance rather than treated automatically.

Future research should prioritize high-quality prospective cohort studies that determine whether specific dyskinesis patterns predict shoulder pain or injury when combined with workload, fatigue, strength, and kinetic-chain variables. Randomized trials should compare standardized scapular-focused rehabilitation protocols with conventional shoulder programs and report outcomes using consistent pain, function, kinematic, and sport-performance measures. Studies should also investigate dose-response relationships, return-to-sport criteria, and long-term recurrence rates. Establishing standardized assessment methods and clinically meaningful thresholds would improve comparability across studies and help determine which athletes benefit most from targeted scapular intervention.

CONCLUSION

Scapular dyskinesis is a clinically relevant but context-dependent movement-control impairment in overhead athletes, with current evidence suggesting associations with altered scapular kinematics,

impaired neuromuscular control, shoulder pain, functional limitation, reduced performance efficiency, and potentially increased injury susceptibility. Its presence should not be interpreted as pathological in isolation, particularly because dyskinesia may also occur in asymptomatic athletes; rather, it is most meaningful when accompanied by pain, fatigue, weakness, impaired scapulohumeral rhythm, or sport-specific performance deficits. Clinical assessment and rehabilitation should therefore integrate scapular motion analysis, neuromuscular control, muscle balance, load management, and progressive sport-specific retraining to improve shoulder function and support safe return to overhead activity. Future research should focus on standardized assessment methods, prospective injury-risk models, and well-designed rehabilitation trials to clarify causal pathways and optimize evidence-based management for overhead athletes.

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