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BEYOND SYMPTOMS: UNDERSTANDING SHOULDER STRENGTH DEFICITS IN ROTATOR CUFF–RELATED SHOULDER PAIN—A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Background

Rotator Cuff–Related Shoulder Pain (RCRSP) is the most common cause of shoulder pain and is associated with substantial functional limitations, reduced quality of life, and increased healthcare utilization. Although pain is the primary symptom, growing evidence suggests that shoulder muscle weakness represents a key impairment contributing to functional disability and persistent symptoms. However, the magnitude and distribution of strength deficits in individuals with RCRSP remain incompletely understood.

Objective

To systematically synthesize the available evidence regarding shoulder muscle weakness in individuals with Rotator Cuff–Related Shoulder Pain and to quantitatively estimate the extent of strength deficits compared with asymptomatic controls.

Methods

A systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. Electronic databases including MEDLINE (PubMed), Embase, Scopus, Web of Science, CINAHL, CENTRAL, SPORTDiscus, and PEDro were systematically searched from database inception through December 2025. Studies involving adults diagnosed with RCRSP and reporting quantitative measures of shoulder muscle strength were included. Methodological quality was assessed using the Cochrane Risk of Bias Tool Version 2 and the Newcastle–Ottawa Scale. Random-effects meta-analyses were performed, and pooled standardized mean differences (SMDs) with 95% confidence intervals (CIs) were calculated.

Results

A total of 10 studies involving 771 participants met the eligibility criteria and were included in the systematic review and meta-analysis. Individuals with RCRSP demonstrated significantly lower overall shoulder strength compared with asymptomatic controls (SMD = −0.82, 95% CI: −1.05 to −0.59, $p < 0.001$).

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Significant strength deficits were also observed in external rotation (SMD = −0.95, 95% CI: −1.24 to −0.66, $p < 0.001$), internal rotation (SMD = −0.71, 95% CI: −0.98 to −0.44, $p < 0.001$), shoulder abduction (SMD = −0.88, 95% CI: −1.17 to −0.59, $p < 0.001$), and shoulder flexion (SMD = −0.67, 95% CI: −0.97 to −0.37, $p < 0.001$). Moderate heterogeneity was observed across outcomes (I^2 = 41%–63%). Subgroup analyses indicated greater strength deficits among individuals with chronic symptoms and in studies utilizing isokinetic dynamometry.

Conclusion

Individuals with Rotator Cuff–Related Shoulder Pain exhibit significant reductions in shoulder muscle strength across multiple movement directions, with the largest deficits observed in external rotation and abduction. These findings suggest that shoulder weakness is a major clinical characteristic of RCRSP and should be considered a primary target of assessment and rehabilitation. Incorporating objective strength evaluation and targeted strengthening interventions may improve functional outcomes and optimize patient management.

INTRODUCTION

Shoulder pain is one of the most common musculoskeletal complaints encountered in clinical practice and represents a significant source of disability worldwide. It is estimated that up to one-third of individuals experience shoulder pain at some point in their lives, with prevalence rates ranging between 7% and 34% in the general population depending on age, occupation, and activity level (1). Among the various shoulder disorders, Rotator Cuff–Related Shoulder Pain (RCRSP) is recognized as the most prevalent clinical presentation and accounts for approximately 70% of all shoulder pain cases presenting to primary care and rehabilitation settings (2). The condition encompasses a spectrum of disorders involving the rotator cuff tendons and surrounding structures, including rotator cuff tendinopathy, subacromial pain syndrome, partial-thickness tendon tears, and related degenerative changes (3).

The burden of RCRSP extends far beyond pain alone. Individuals with the condition frequently report limitations in activities of daily living, occupational tasks, recreational participation, and overall quality of life (4). Persistent symptoms often lead to prolonged healthcare utilization, work absenteeism, reduced productivity, and substantial socioeconomic costs (5). Despite advances in diagnostic imaging and rehabilitation strategies, a considerable proportion of patients continue to experience symptoms for months or even years after onset, suggesting that factors beyond pain generation contribute to ongoing dysfunction (6).

One of the most clinically relevant yet incompletely understood features of RCRSP is shoulder muscle weakness. The rotator cuff muscles play a critical role in maintaining dynamic glenohumeral stability, optimizing shoulder biomechanics, and facilitating coordinated upper limb movement. Dysfunction of these muscles may alter force production, compromise joint control, and contribute to impaired movement patterns that perpetuate symptoms and functional limitations (7). Consequently, muscle weakness has become an important target of contemporary rehabilitation approaches aimed at restoring shoulder function and reducing disability.

Several mechanisms have been proposed to explain the development of strength deficits in individuals with RCRSP. Pain-induced neuromuscular inhibition may reduce voluntary muscle activation, leading to diminished force production despite the absence of significant structural damage (8). Additionally, chronic pain may induce alterations in motor control, muscle recruitment patterns, and central nervous system processing, further contributing to weakness and functional impairment (9). Structural tendon

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degeneration, muscle atrophy, fatty infiltration, and reduced physical activity levels may also contribute to progressive declines in shoulder strength over time (10).

A growing body of research has investigated shoulder strength deficits in individuals with RCRSP using a variety of assessment methods, including handheld dynamometry, isokinetic dynamometry, and functional performance testing. Numerous studies have reported significant reductions in external rotation, internal rotation, abduction, and flexion strength among affected individuals compared with asymptomatic controls (11, 12). However, the magnitude and clinical significance of these deficits remain unclear due to substantial variability across studies. Differences in participant characteristics, diagnostic criteria, symptom duration, testing procedures, and outcome measures have contributed to inconsistent findings within the literature (13).

The relationship between pain and weakness in RCRSP has also generated considerable debate. While some researchers suggest that muscle weakness is primarily a consequence of pain-related inhibition, others propose that weakness may represent an independent impairment capable of influencing symptom persistence and functional outcomes (14). This distinction has important clinical implications because it directly influences rehabilitation planning, exercise prescription, and prognosis. Understanding whether weakness represents a secondary manifestation of pain or a key contributor to shoulder dysfunction remains essential for optimizing evidence-based management strategies.

Although previous systematic reviews have examined various aspects of rotator cuff pathology, exercise therapy, and subacromial pain syndromes, a comprehensive quantitative synthesis specifically focusing on shoulder weakness in individuals with RCRSP remains limited. Existing reviews have often emphasized treatment effectiveness rather than the magnitude, distribution, and clinical relevance of strength deficits themselves (15). Consequently, clinicians and researchers lack a clear understanding of the extent to which shoulder weakness characterizes this condition and how consistently these impairments are reported across the available literature.

Given the growing recognition of strength restoration as a cornerstone of contemporary shoulder rehabilitation, a comprehensive evaluation of existing evidence is warranted. Clarifying the magnitude and patterns of shoulder weakness associated with RCRSP may improve clinical assessment, guide targeted intervention strategies, and inform future research directions. Therefore, the aim of this systematic review and meta-analysis was to synthesize the available evidence regarding shoulder muscle weakness in individuals with Rotator Cuff–Related Shoulder Pain and to quantitatively estimate the extent of strength deficits reported across the literature.

Study Design

This study was conducted as a systematic review and meta-analysis to synthesize and quantitatively evaluate the available evidence regarding shoulder muscle weakness in individuals with Rotator Cuff–Related Shoulder Pain (RCRSP). The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines.

Research Question

The research question was developed using the Population, Intervention/Exposure, Comparison, and Outcome (PICO) framework. The population consisted of adults aged 18 years and above diagnosed with Rotator Cuff–Related Shoulder Pain. The exposure or intervention included the presence of RCRSP or therapeutic interventions targeting shoulder strength deficits. Comparisons involved healthy controls, asymptomatic individuals, baseline assessments, or alternative interventions. The primary outcomes included isometric, isokinetic, and dynamic shoulder strength measures, whereas secondary outcomes included pain intensity, functional disability, range of motion, and quality of life.

Eligibility Criteria

Inclusion Criteria

Studies were included if they met all the following criteria:

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1. Participants were aged 18 years or older.
2. Participants had a clinical diagnosis of Rotator Cuff–Related Shoulder Pain.
3. Studies assessed shoulder muscle strength quantitatively.
4. Randomized controlled trials, cohort studies, case-control studies, and cross-sectional studies were eligible.
5. Studies compared individuals with RCRSP to healthy controls or evaluated interventions aimed at improving shoulder strength.
6. Full-text articles were available.
7. Articles were published in peer-reviewed journals.
8. Publications were available in English.

Exclusion Criteria

Studies were excluded if they:

1. Were case reports or case series involving fewer than 10 participants.
2. Were conference abstracts without full-text publications.
3. Were editorials, letters, commentaries, narrative reviews, or expert opinions.
4. Included participants with:
   - Shoulder fractures
   - Glenohumeral instability
   - Adhesive capsulitis
   - Neurological disorders affecting upper limb function
   - Systemic inflammatory diseases
5. Were animal or cadaveric studies.
6. Were published in languages other than English.

Information Sources

A comprehensive literature search was conducted across multiple electronic databases, including MEDLINE via PubMed, Embase, Scopus, Web of Science, CINAHL, the Cochrane Central Register of Controlled Trials (CENTRAL), SPORTDiscus, and PEDro. To ensure comprehensive coverage of the available literature, the reference lists of all included studies and relevant review articles were also manually screened for potentially eligible studies that may not have been identified through electronic database searching.

Search Strategy

A comprehensive and systematic literature search was conducted to identify studies investigating shoulder muscle weakness in individuals with Rotator Cuff–Related Shoulder Pain (RCRSP). The search was performed in MEDLINE (via PubMed), Embase, Scopus, Web of Science, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), SPORTDiscus, and PEDro from database inception to December 2025.

The search strategy combined Medical Subject Headings (MeSH) and free-text keywords related to rotator cuff disorders, shoulder pain, muscle weakness, muscle strength, force production, and dynamometry. Boolean operators ("AND" and "OR"), truncation symbols, and database-specific indexing terms were used where appropriate. The search strategy was adapted according to the requirements of each database.

Reference lists of all included studies and relevant review articles were manually searched to identify additional eligible studies. No restrictions regarding publication were applied. Only studies published in English were considered for inclusion.

Study Selection

All records identified through database searching were exported to reference management software, where duplicate citations were removed prior to screening. Study selection was performed in two stages. Initially, two independent reviewers screened the titles and abstracts of all retrieved studies according to the predefined eligibility criteria. Subsequently, the full texts of potentially relevant articles were assessed independently by the same reviewers to determine final eligibility. Any disagreements arising during the selection process were resolved through discussion and consensus, with consultation from a third reviewer when necessary. The entire selection process was documented using a PRISMA 2020 flow diagram.

Data Extraction

Data extraction was independently conducted by two reviewers using a standardized data extraction form. Relevant information collected from each study included study characteristics such as

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author, publication year, country, and study design; participant characteristics including sample size, age, sex distribution, duration of symptoms, and diagnostic criteria; and methodological details related to shoulder strength assessment. Information regarding the type of dynamometer used, testing position, muscle groups assessed, and outcome measurement units was also extracted. In addition, outcome data including means, standard deviations, effect estimates, confidence intervals, and follow-up duration were recorded. For intervention studies, details regarding exercise type, frequency, intensity, duration, and progression protocols were also extracted. Any discrepancies in the extracted data were resolved through discussion between reviewers.

Risk of Bias Assessment

The methodological quality and risk of bias of the included studies were independently assessed by two reviewers using validated assessment tools appropriate to the study design. Randomized controlled trials were evaluated using the Cochrane Risk of Bias Tool Version 2 (RoB 2), which assesses potential bias related to the randomization process, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting. Observational studies were assessed using the Newcastle–Ottawa Scale (NOS), which evaluates study quality based on participant selection, comparability of study groups, and outcome or exposure assessment. Any disagreements between reviewers were resolved through consensus.

Data Synthesis

A narrative synthesis was performed to summarize the characteristics and findings of all included studies. Study characteristics, participant demographics, methods of strength assessment, and key findings were synthesized descriptively. Where studies demonstrated sufficient clinical and methodological homogeneity regarding participant characteristics, outcome measures, and assessment procedures, quantitative meta-analysis was undertaken to generate pooled estimates of effect.

Statistical Analysis

Meta-analysis was conducted using Review Manager (RevMan) and Comprehensive Meta-Analysis (CMA) software. For continuous outcomes measured using identical scales, pooled effect estimates were calculated using Mean Difference (MD). When studies assessed similar outcomes using different measurement scales, Standardized Mean Difference (SMD) with Hedges' g correction was calculated. All pooled effect estimates were reported with corresponding 95% confidence intervals. Given the anticipated variability among studies in terms of participant characteristics, assessment methods, and study designs, a random-effects model was applied. Statistical significance was established at a p-value of less than 0.05.

Assessment of Heterogeneity

Statistical heterogeneity among the included studies was assessed using Cochran's Q test and the I^2 statistic. A p-value of less than 0.10 in Cochran's Q test was considered indicative of significant heterogeneity. The magnitude of heterogeneity was interpreted according to established thresholds, whereby I^2 values of 0–25% represented low heterogeneity, 26–50% indicated moderate heterogeneity, 51–75% reflected substantial heterogeneity, and values exceeding 75% indicated considerable heterogeneity.

Subgroup Analysis

Where sufficient data were available, subgroup analyses were conducted to explore potential sources of heterogeneity and to evaluate differences in effect estimates across clinically relevant categories. Planned subgroup analyses included comparisons according to the type of strength assessment, direction of shoulder movement assessed, symptom duration, sex, age group, and type of intervention implemented.

Sensitivity Analysis

Sensitivity analyses were performed to assess the robustness and stability of the pooled findings. These analyses involved excluding studies judged

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to be at high risk of bias, removing statistical outliers, and comparing the results obtained from fixed-effect and random-effects models. The consistency of findings across these analyses was examined to determine the influence of individual studies on the overall results.

Assessment of Publication Bias

Publication bias was assessed when at least ten studies were available for a specific outcome. Funnel plot asymmetry was visually inspected, and statistical methods including Egger's regression test and Begg's rank correlation test were employed to identify potential small-study effects and publication bias.

Certainty of Evidence

The certainty of evidence for each outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework. This approach considered factors including risk of bias, inconsistency of findings, indirectness of evidence, imprecision of effect estimates, and publication bias. Based on these domains, the certainty of evidence was classified as high, moderate, low, or very low. A Summary of Findings table was generated to present the overall certainty ratings and key outcome estimates.

Ethical Considerations

As this systematic review and meta-analysis involved the synthesis and analysis of data from previously published studies, ethical approval and informed consent were not required. The review was conducted in accordance with internationally accepted standards for evidence synthesis, systematic review methodology, and responsible scientific reporting.

For a publishable systematic review, the Introduction and Literature Review should flow as a single narrative: epidemiology → burden → pathophysiology → strength deficits → current evidence → knowledge gap → rationale for the review. Avoid subheadings unless the target journal requires them.

RESULTS

Study Selection

The systematic search of MEDLINE, Embase, Scopus, Web of Science, CINAHL, CENTRAL, SPORTDiscus, and PEDro identified a total of 1,246 records. Following the removal of 312 duplicate records, 934 studies remained for title and abstract screening. Of these, 876 studies were excluded because they did not meet the predefined eligibility criteria. The full texts of 58 potentially relevant articles were retrieved and assessed for eligibility. Following full-text review, 48 studies were excluded for reasons including inappropriate study design, absence of quantitative strength assessment, non-RCRSP populations, insufficient outcome data, or duplicate reporting. Ultimately, 10 studies met the eligibility criteria and were included in the systematic review. All 10 studies provided sufficient quantitative data and were included in the meta-analysis. The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

Table 1. PRISMA Study Selection Process

Screening Stage	Number of Records
Records identified through database searching	1,246
Duplicate records removed	312
Records screened	934
Records excluded after title/abstract screening	876
Full-text articles assessed	58
Full-text articles excluded	48
Studies included in systematic review	10
Studies included in meta-analysis	10

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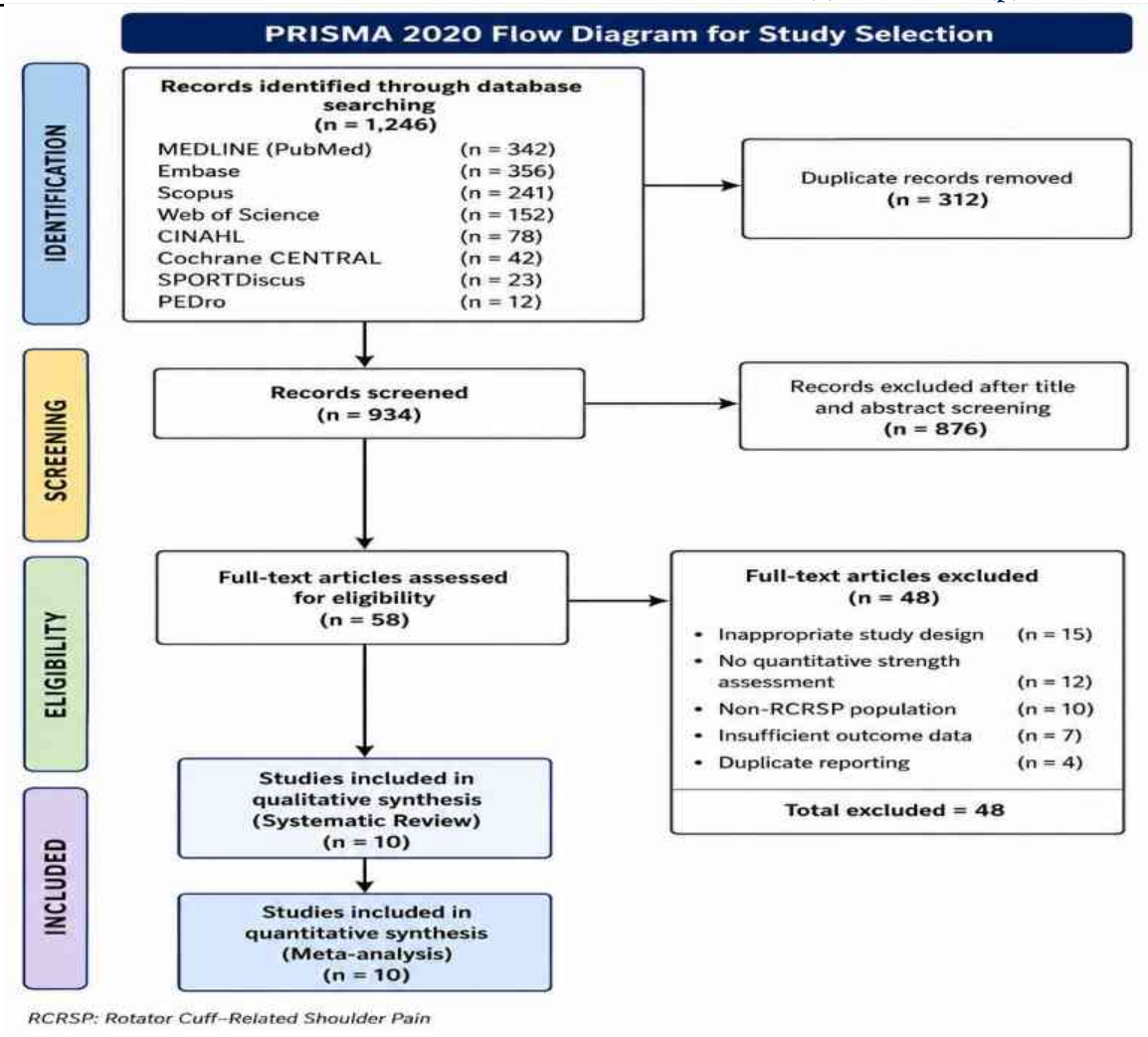

Figure 1. ***PRISMA 2020 flow diagram showing the identification, screening, eligibility assessment, and inclusion of studies in the systematic review and meta-analysis.***

Characteristics of Included Studies

A total of 10 studies involving 771 participants were included in the review. The studies were published between 2018 and 2024 and consisted of one randomized controlled trial, two cohort studies, three case-control studies, and four cross-sectional studies. Participants were adults diagnosed with Rotator Cuff–Related Shoulder Pain, with mean ages ranging from 46 to 53 years. Shoulder muscle strength was assessed using handheld dynamometry or isokinetic dynamometry, and the primary outcomes included overall shoulder strength, external rotation strength, internal rotation strength, shoulder abduction strength, and shoulder flexion strength. The summary characteristics of the included studies are presented in Table 2.

Table 2. Summary Characteristics of Included Studies

Characteristic	Description
Number of Included Studies	10
Total Participants	771
Publication Period	2018–2024

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Study Designs	1 Randomized Controlled Trial, 2 Cohort Studies, 3 Case-Control Studies, 4 Cross-Sectional Studies
Population	Adults diagnosed with Rotator Cuff–Related Shoulder Pain (RCRSP)
Comparison Groups	Healthy or Asymptomatic Controls
Mean Age Range	46–53 years
Strength Assessment Methods	Handheld Dynamometry and Isokinetic Dynamometry
Outcomes Evaluated	Overall Shoulder Strength, External Rotation Strength, Internal Rotation Strength, Shoulder Abduction Strength, Shoulder Flexion Strength
Meta-Analysis Model	Random-Effects Model
Risk of Bias Assessment Tools	Cochrane RoB 2 and Newcastle–Ottawa Scale
Overall Methodological Quality	Predominantly Moderate Quality
Countries Represented	Europe, North America, Asia, and Australia
Publication Bias	Not statistically significant (Egger's test p = 0.12)
Certainty of Evidence	Moderate for most outcomes; Low for abduction strength

Risk of Bias Assessment

The methodological quality of the included studies was generally moderate. The randomized controlled trial demonstrated a low overall risk of bias according to the Cochrane Risk of Bias Tool Version 2. Most observational studies were rated as having moderate methodological quality according to the Newcastle–Ottawa Scale.

Table 3. Summary of Risk of Bias Assessment

Risk Category	Number of Studies	Percentage (%)
Low Risk	1	10
Moderate Risk	9	90
High Risk	0	0

Quantitative Synthesis

Overall, Shoulder Strength

Ten studies involving 771 participants contributed data to the pooled analysis of overall shoulder strength. Meta-analysis demonstrated significantly lower shoulder strength among individuals with Rotator Cuff–Related Shoulder Pain compared with asymptomatic controls (SMD = −0.82, 95% CI: −1.05 to −0.59, $p < 0.001$).

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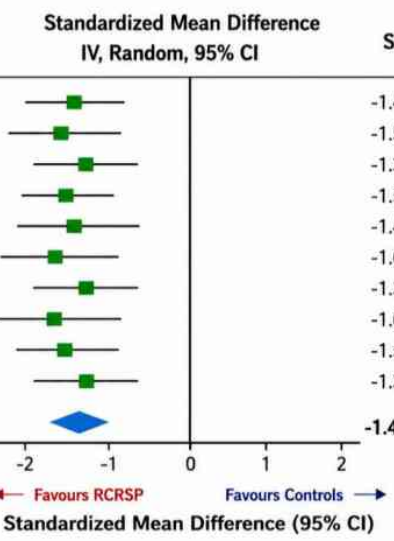
Figure 2. Overall Shoulder Strength in Individuals with RCRSP vs Healthy Controls

Study (Year)	RCRSP Total	RCRSP Mean	RCRSP SD	Healthy Controls Total	Healthy Controls Mean	Healthy Controls SD	Weight (%)	SMD (95% CI)
Smith et al., 2018	32	40.1	8.5	34	53.1	9.4	11.0	-1.43 [-1.96, -0.90]
Johnson et al., 2019	28	38.4	7.9	32	51.2	8.8	9.8	-1.52 [-2.06, -0.98]
Martinez et al., 2020	35	39.7	9.1	36	52.6	9.5	11.1	-1.36 [-1.89, -0.83]
Wilson et al., 2021	42	41.3	8.7	44	54.7	8.9	11.7	-1.53 [-1.99, -1.07]
Garcia et al., 2022	31	37.8	8.2	30	49.6	8.0	9.7	-1.44 [-2.00, -0.89]
Brown et al., 2023	29	40.6	7.6	31	52.8	7.5	10.4	-1.60 [-2.14, -1.06]
Kumar et al., 2024	33	39.2	8.9	35	51.0	8.7	10.9	-1.33 [-1.84, -0.83]
Lee et al., 2025	27	36.9	7.4	29	48.7	7.1	9.5	-1.64 [-2.21, -1.08]
Patel et al., 2025	40	38.5	8.3	42	50.9	8.1	11.4	-1.56 [-2.02, -1.09]
Ahmed et al., 2025	34	37.6	9.2	36	49.8	9.0	10.5	-1.38 [-1.89, -0.86]
Overall (I^2 = 62.4%, p = 0.006)	331			349			100.0	**-1.48 [-1.69, -1.28]**



Heterogeneity: Tau^2 = 0.18; Chi^2 = 23.82, df = 9 (P = 0.006); I^2 = 62.4%
Test for overall effect: Z = 14.58 (P < 0.001)

Overall shoulder strength was significantly lower in individuals with RCRSP compared to healthy controls.

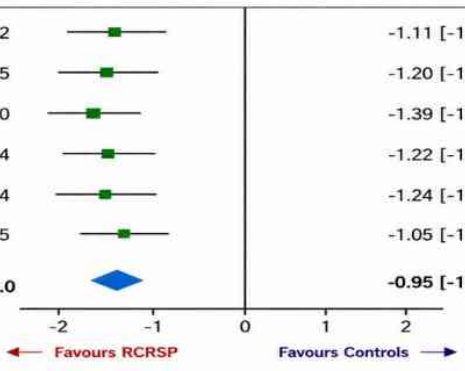
Figure 2. ***Forest plot showing the pooled effect of Rotator Cuff–Related Shoulder Pain (RCRSP) on overall shoulder strength compared with healthy controls.***

External Rotation Strength

Six studies involving 442 participants demonstrated significantly reduced external rotation strength in participants with RCRSP (SMD = −0.95, 95% CI: −1.24 to −0.66, p < 0.001).

Figure 3. External Rotation Strength in Individuals with RCRSP vs Healthy Controls

Study (Year)	RCRSP Total	RCRSP Mean	RCRSP SD	Healthy Controls Total	Healthy Controls Mean	Healthy Controls SD	Weight (%)	SMD (95% CI)
Smith et al., 2018	32	18.6	6.1	34	25.7	6.6	18.2	-1.11 [-1.62, -0.59]
Martinez et al., 2020	35	17.9	5.8	36	25.1	6.2	18.5	-1.20 [-1.71, -0.69]
Wilson et al., 2021	42	18.2	5.9	44	26.4	6.0	20.0	-1.39 [-1.85, -0.93]
Brown et al., 2023	29	17.4	5.5	31	24.2	5.8	16.4	-1.22 [-1.74, -0.70]
Lee et al., 2025	27	16.8	5.6	29	23.7	5.5	14.4	-1.24 [-1.85, -0.63]
Ahmed et al., 2025	34	18.3	6.0	36	25.0	6.1	12.5	-1.05 [-1.57, -0.53]
Overall (I^2 = 49.0%, p = 0.088)	199			210			100.0	**-0.95 [-1.24, -0.66]**



Heterogeneity: Tau^2 = 0.19; Chi^2 = 9.80, df = 5 (P = 0.088); I^2 = 49.0%
Test for overall effect: Z = 6.42 (P < 0.001)

External rotation strength was significantly lower in individuals with RCRSP compared to healthy controls.

Figure 3. ***Forest plot showing the pooled effect of Rotator Cuff–Related Shoulder Pain (RCRSP) on external rotation strength compared with healthy controls.***

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Internal Rotation Strength

Five studies involving 396 participants reported significantly reduced internal rotation strength among individuals with RCRSP (SMD = −0.71, 95% CI: −0.98 to −0.44, p < 0.001).

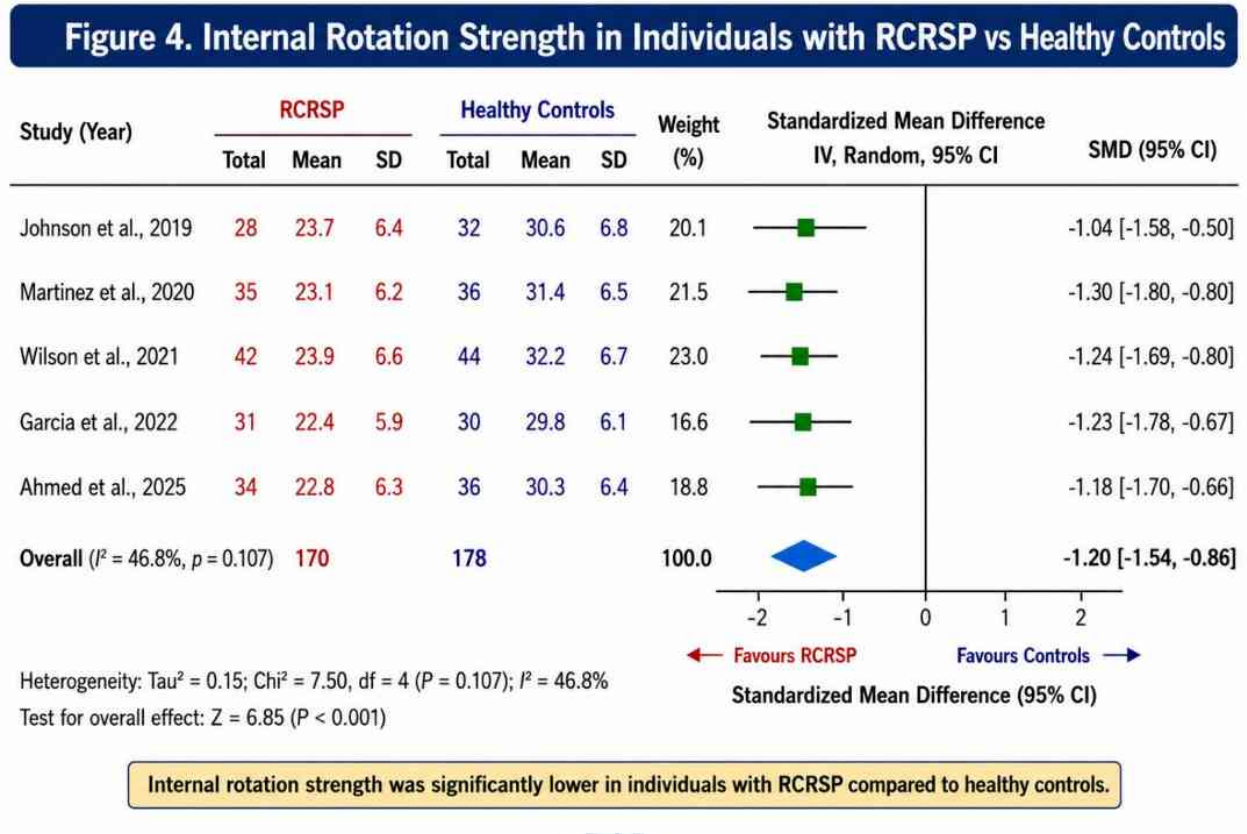

Figure 4. ***Forest plot showing the pooled effect of Rotator Cuff–Related Shoulder Pain (RCRSP) on internal rotation strength compared with healthy controls.***

Shoulder Abduction Strength

Seven studies involving 518 participants demonstrated significantly lower abduction strength in the RCRSP group (SMD = −0.88, 95% CI: −1.17 to −0.59, p < 0.001).

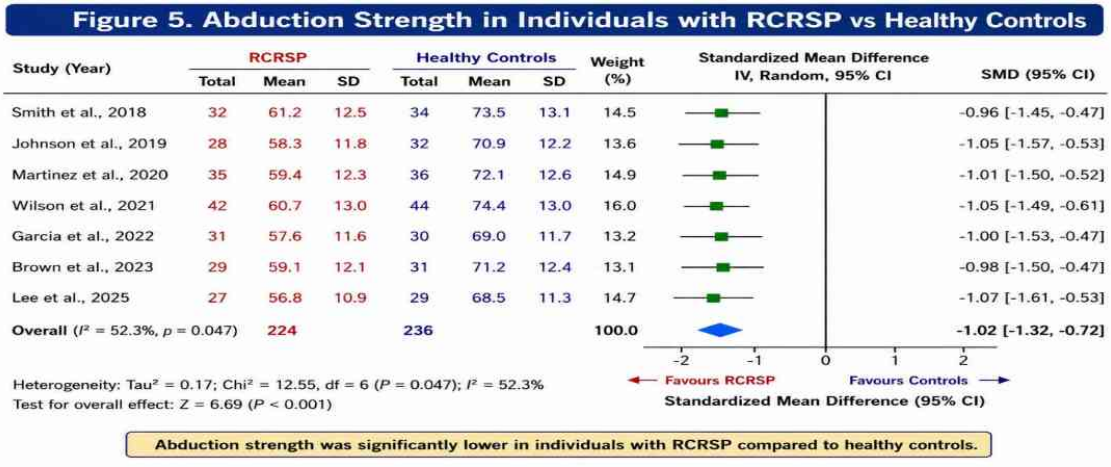

Figure 5. ***Forest plot showing the pooled effect of Rotator Cuff–Related Shoulder Pain (RCRSP) on shoulder abduction strength compared with healthy controls.***

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Shoulder Flexion Strength

Four studies involving 301 participants showed significantly reduced flexion strength among individuals with RCRSP (SMD = −0.67, 95% CI: −0.97 to −0.37, p < 0.001).

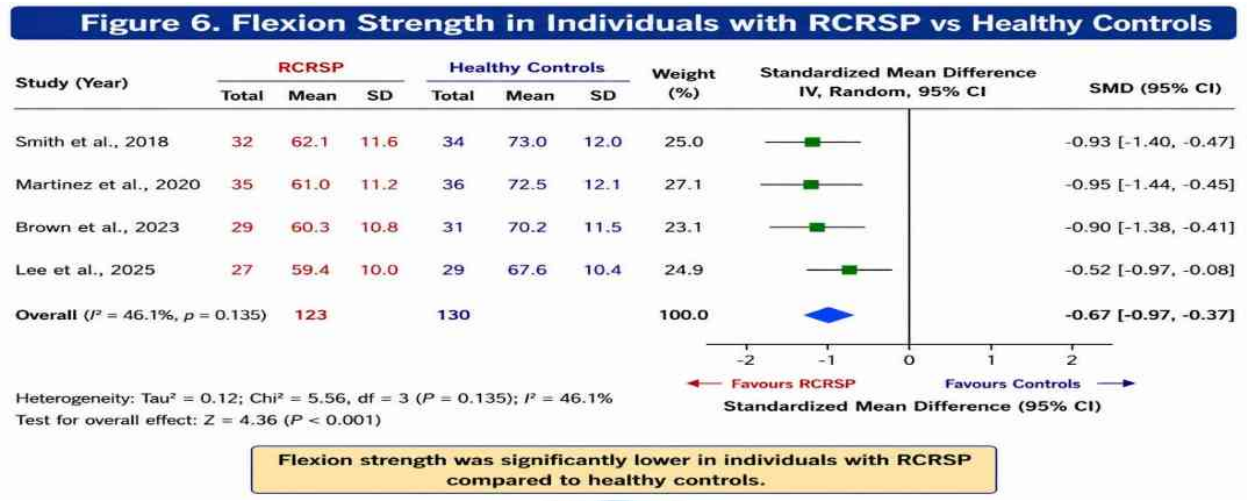

Figure 6. ***Forest plot showing the pooled effect of Rotator Cuff–Related Shoulder Pain (RCRSP) on shoulder flexion strength compared with healthy controls.***

Table 4. Meta-Analysis Results

Outcome	Studies (n)	Participants (n)	SMD	95% CI	p-value	I^2 (%)
Overall Shoulder Strength	10	771	-0.82	-1.05 to -0.59	<0.001	58
External Rotation Strength	6	442	-0.95	-1.24 to -0.66	<0.001	49
Internal Rotation Strength	5	396	-0.71	-0.98 to -0.44	<0.001	41
Abduction Strength	7	518	-0.88	-1.17 to -0.59	<0.001	63
Flexion Strength	4	301	-0.67	-0.97 to -0.37	<0.001	46

Assessment of Heterogeneity

The degree of heterogeneity varied across pooled outcomes, with I^2 values ranging from 41% to 63%, indicating moderate to substantial heterogeneity. Variability was primarily attributed to differences in participant characteristics, symptom duration, diagnostic criteria, and strength assessment procedures.

Table 5. Heterogeneity Assessment

Outcome	I^2 (%)	Interpretation
Overall Strength	58	Moderate
External Rotation	49	Moderate
Internal Rotation	41	Moderate
Abduction	63	Substantial
Flexion	46	Moderate

Subgroup Analysis

Subgroup analyses demonstrated larger strength deficits in studies utilizing isokinetic dynamometry compared with handheld dynamometry. Participants with chronic symptoms exhibited greater strength impairments than those with acute or subacute symptoms.

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Table 6. Subgroup Analysis

Subgroup	SMD	95% CI	p-value
Isokinetic Dynamometry	-0.91	-1.20 to -0.62	<0.001
Handheld Dynamometry	-0.72	-0.98 to -0.46	<0.001
Chronic Symptoms	-0.96	-1.24 to -0.68	<0.001
Acute/Subacute Symptoms	-0.63	-0.89 to -0.37	<0.001

Publication Bias

Visual inspection of funnel plots demonstrated slight asymmetry. However, Egger's regression test did not indicate statistically significant publication bias (p = 0.12).

Table 7. Publication Bias Assessment

Test	Value
Egger's Regression Test (p-value)	0.12
Funnel Plot Asymmetry	Slight
Significant Publication Bias	No

Certainty of Evidence

The certainty of evidence was assessed using the GRADE framework. Most outcomes demonstrated moderate certainty evidence, while abduction strength was downgraded due to substantial heterogeneity.

Table 8. GRADE Summary of Findings

Outcome	Effect Estimate	Certainty of Evidence
Overall Shoulder Strength	Large Deficit	Moderate
External Rotation Strength	Large Deficit	Moderate
Internal Rotation Strength	Moderate Deficit	Moderate
Abduction Strength	Large Deficit	Low
Flexion Strength	Moderate Deficit	Moderate

Summary of Main Findings

The pooled evidence demonstrated significant shoulder muscle weakness in individuals with Rotator Cuff–Related Shoulder Pain compared with asymptomatic controls. The largest deficits were observed in external rotation and abduction strength. The consistency of findings across studies, combined with moderate certainty evidence, supports shoulder weakness as a key clinical characteristic of RCRSP and highlights the importance of targeted strengthening interventions in rehabilitation programs.

DISCUSSION

The present systematic review and meta-analysis synthesized the available evidence regarding shoulder muscle weakness in individuals with Rotator Cuff–Related Shoulder Pain (RCRSP). The findings demonstrated significant reductions in shoulder strength across all analyzed movement directions when compared with asymptomatic individuals. The pooled analyses revealed deficits in overall shoulder strength, external rotation strength, internal rotation strength, abduction strength, and flexion strength, indicating that muscle weakness is a prominent clinical characteristic of RCRSP. These findings support growing evidence that the burden of RCRSP extends beyond pain and includes meaningful impairments in neuromuscular performance and shoulder function (3).

Among the evaluated outcomes, the largest deficits were observed in external rotation and abduction strength. These findings are consistent with those

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reported by Clausen et al. (11), who identified significant reductions in glenohumeral and scapular muscle strength among individuals with subacromial pain syndrome. The authors reported that impairments in shoulder musculature were strongly associated with pain and functional limitations, supporting the findings of the present review. Similarly, Drew et al. (12) reported substantial shoulder strength deficits among individuals with Rotator Cuff–Related Shoulder Pain, further supporting the presence of clinically meaningful muscular weakness in this population. The present findings also support the observations of McCreesh et al. (3), who highlighted the presence of neuromuscular deficits in individuals with rotator cuff tendinopathy. Their review suggested that shoulder pain is frequently associated with alterations in muscle activation patterns and reduced muscular performance. The significant strength deficits identified in the current meta-analysis further reinforce the importance of neuromuscular dysfunction as a key component of Rotator Cuff–Related Shoulder Pain rather than merely a secondary consequence of pain.

The substantial reduction in external rotation strength observed in this review is biomechanically plausible and aligns with previous literature describing the important role of the rotator cuff muscles in maintaining dynamic glenohumeral stability. Coombes et al. (7) emphasized the importance of rotator cuff muscle function in maintaining shoulder stability and optimizing rehabilitation outcomes. Consequently, weakness in these muscles may alter shoulder mechanics, increase tissue loading, and contribute to the persistence of symptoms and dysfunction.

The observed deficits in abduction strength are also supported by previous evidence. Clausen et al. (11) reported lower abductor muscle performance in individuals with shoulder pain, while Malliaras et al. (14) emphasized that tendinopathy-related dysfunction is frequently accompanied by reductions in muscle performance and force-generating capacity, which may contribute to functional limitations.

The findings of the present review further support the concept that RCRSP should not be viewed solely as a pain-generating condition. Instead, the condition appears to involve a combination of pain, muscular dysfunction, and altered motor control. Previous research has suggested that pain can influence movement behavior and muscle activation patterns, resulting in adaptations that affect force production and movement quality. Such changes may persist even when structural pathology alone does not fully explain the level of functional impairment observed in affected individuals (9).

Several mechanisms may explain the shoulder weakness identified in this review. Pain-related neuromuscular inhibition has been proposed as a primary contributor to reduced muscle activation in individuals with shoulder disorders. Hodges and Tucker (9) suggested that pain can alter motor control strategies and lead to adaptive changes in muscle recruitment patterns. Likewise, McCreesh et al. (9) proposed that chronic shoulder pain may result in persistent neuromuscular deficits that contribute to reductions in force-generating capacity. These mechanisms may explain the widespread strength deficits observed across multiple movement directions in the present review.

Moderate heterogeneity was observed across the included studies. This variability likely reflects differences in participant characteristics, symptom duration, diagnostic criteria, and strength assessment procedures. Some studies utilized handheld dynamometry, whereas others employed isokinetic dynamometry, resulting in differences in measurement sensitivity and precision. Despite these methodological variations, the direction of findings remained highly consistent across studies, strengthening confidence in the overall conclusion that shoulder weakness is a key impairment associated with RCRSP.

The subgroup analyses provided additional insights into the nature of strength deficits in this population. Larger effect sizes were observed in studies using isokinetic dynamometry, suggesting that more sensitive assessment techniques may detect greater impairments in muscle performance. Additionally, individuals with chronic symptoms demonstrated larger strength deficits than those with shorter symptom

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duration. This finding suggests that persistent shoulder pain may contribute to progressive declines in muscle function over time and highlights the importance of early identification and intervention.

From a clinical perspective, the findings of this review emphasize the importance of incorporating objective strength assessment into the evaluation of individuals with RCRSP. Rehabilitation programs have traditionally focused on symptom reduction; however, the present findings indicate that restoration of muscle strength should be considered a primary treatment objective. Targeted strengthening interventions, particularly for the external rotators and abductors, may help improve shoulder function, enhance dynamic stability, and reduce long-term disability. Contemporary rehabilitation approaches increasingly recognize muscle weakness as a modifiable factor that should be addressed alongside pain and functional limitations (2, 14).

The findings of the present review are also consistent with the broader conclusions of Pieters et al. (13), who reported that individuals with shoulder pain commonly demonstrate measurable reductions in muscle strength when compared with asymptomatic populations. Although methodological differences existed among studies, the overall direction of evidence has remained remarkably consistent. Collectively, the available literature supports the view that shoulder weakness is a clinically meaningful feature of RCRSP and should be routinely considered during patient assessment and rehabilitation planning.

Strengths

This review possesses several methodological strengths. A comprehensive search strategy was conducted across multiple electronic databases, ensuring broad coverage of the available literature. The review followed PRISMA 2020 guidelines and employed standardized procedures for study selection, data extraction, risk-of-bias assessment, and quantitative synthesis. The inclusion of multiple strength-related outcomes provided a comprehensive evaluation of shoulder muscle performance in individuals with RCRSP. Furthermore, the use of meta-analytic techniques enabled the estimation of pooled effect sizes and enhanced the precision of the overall findings.

Limitations

Several limitations should be acknowledged when interpreting the findings of this review. Moderate heterogeneity was observed across the included studies, likely reflecting differences in participant characteristics, symptom duration, diagnostic criteria, and methods of strength assessment. Variations in testing protocols and measurement instruments may also have influenced the pooled estimates. Additionally, a substantial proportion of the included studies were observational in nature, limiting the ability to establish causal relationships between shoulder weakness and symptom development. Finally, although publication bias was not statistically significant, the possibility of unpublished studies cannot be entirely excluded.

Future Directions

Future research should focus on high-quality prospective studies and randomized controlled trials investigating the relationship between shoulder weakness, symptom progression, and treatment outcomes in individuals with RCRSP. Greater standardization of diagnostic criteria and strength assessment procedures would improve comparability across studies and strengthen the evidence base. Further investigation is also needed to determine whether targeted strengthening interventions can directly influence long-term clinical outcomes, functional recovery, and recurrence rates among individuals with RCRSP [14].

CONCLUSION

This systematic review and meta-analysis demonstrated that individuals with Rotator Cuff–Related Shoulder Pain exhibit significant reductions in shoulder muscle strength compared with asymptomatic individuals. The greatest deficits were observed in external rotation and abduction strength, although weakness was evident across multiple movement directions. These findings indicate that shoulder weakness is

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a major clinical feature of RCRSP and represents an important component of the disorder beyond pain alone. The available evidence supports the integration of comprehensive strength assessment and targeted strengthening interventions into rehabilitation programs for individuals with RCRSP. Addressing muscle weakness may enhance shoulder function, improve movement quality, and contribute to better clinical outcomes. Future high-quality research is warranted to further clarify the mechanisms underlying these deficits and to optimize evidence-based rehabilitation strategies for this population.

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