RJNMSR
Review Journal of Neurological & Medical Sciences Review
Volume 4, Issue 1, 2026

IMPACT OF HAND GRIP AND SHOULDER MUSCLE STRENGTHENING PROGRAMME ON FUNCTIONAL PERFORMANCE IN ATHLETES

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DOI: https://doi.org/10.5281/zenodo.18410974

Received	Accepted	Published
03 December 2025	13 January 2026	29 January 2026

ABSTRACT

Functional performance in athletes particularly those engaged in sports that require upper limb stability, power, precision, and endurance is influenced significantly by the strength and coordination of the hand grip and shoulder musculature. Hand grip strength (HGS) is a widely used measure of upper limb force production and is considered an indicator of overall athletic strength and neuromuscular readiness. Shoulder muscle strength, particularly of the rotator cuff and stabilizers, is essential for controlling upper limb movement during dynamic sporting actions. Despite the recognized importance of both components, there is limited evidence on the combined effect of a structured hand grip and shoulder strengthening programme on sport related functional performance. This study investigated the effects of an 8 week targeted strengthening intervention on hand grip and shoulder muscle strength and its translation to sport specific functional performance in competitive athletes. Twenty eight athletes (15 males, 13 females; aged 18–30 years) participated in a progressive training protocol involving both hand grip and shoulder strengthening exercises. Outcome measures included hand grip dynamometry, isometric shoulder strength assessments, and sport task performance scores (accuracy, stability, and task execution). Post intervention results demonstrated significant improvements in both strength measures and functional performance outcomes. These findings suggest that integrated upper limb strengthening protocols can enhance athletic performance and should be considered in sport training and rehabilitation programmes.

Keywords: *Hand grip strength; shoulder strengthening; functional performance; athletes; upper limb rehabilitation*

1. Introduction

Athletic performance in sports that involve upper limb activity depends not only on skill and technique but also on the neuromuscular capacity of the upper limb muscles, particularly the hand grip and shoulder complex (Abe et al., 2024). These muscle groups are critical for generating force, stabilizing joints, and executing precise movements during sports such as tennis, volleyball, basketball, archery, swimming, rowing, and weightlifting. In these activities, athletes must maintain upper limb stability while performing dynamic actions, and deficits in either hand grip or shoulder strength can compromise performance and increase injury risk (Cabarkapa et al., 2025).

Hand grip strength (HGS) is one of the most frequently used measures of muscular strength and is considered an indicator of overall upper limb capacity. It involves the maximal force exerted by the flexor muscles of the hand and forearm and is influenced by both intrinsic and extrinsic muscle function (Demiral et al., 2025). HGS has been widely adopted in both athletic assessment and clinical practice because it is reliable, easy to administer, and highly correlated with performance outcomes in multiple sports. In ball sports and racquet sports, grip strength contributes to ball control, racket handling, and shot precision. In wrestling, gymnastics, and climbing, it supports sustained force application and endurance under high demands (Hammad et al., 2024). Multiple studies have confirmed that HGS correlates with other upper limb strength measures, including elbow flexion, shoulder flexion, and push-pull capacities, highlighting its role as a proxy for broader upper limb function (Abe et al., 2025; Bajkowski et al., 2024).

Physiologically, the role of hand grip extends beyond the fingers and forearm. Evidence from electromyographic studies suggests that grip activation, particularly under high force demands, can co-activate shoulder stabilizers such as the rotator cuff and deltoid muscles. This neuromuscular interaction implies that improvements in grip strength may indirectly enhance shoulder function, contributing to better joint stabilization and movement efficiency during dynamic sports actions (Reyhani et al., 2024). Furthermore, grip strength has been shown to be predictive of functional performance in complex motor tasks, such as throwing accuracy, lifting, and maintaining controlled arm positions in sports requiring precision (Karasheva et al., 2025).

The shoulder complex plays an equally critical role in athletic performance. Comprised of muscles responsible for stabilization, rotation, and overhead movements, the shoulder contributes to the transmission of force from the torso to the upper limb and distal extremities. Shoulder strength, particularly of the rotator cuff, deltoids, and scapular stabilizers, is essential for executing high-velocity throwing, striking, and lifting actions. Studies have consistently demonstrated that deficits in shoulder strength reduce performance outcomes, compromise biomechanical efficiency, and increase susceptibility to overuse injuries (Cozette et al., 2026; Vinod et al., 2026). For example, athletes with stronger shoulder stabilizers exhibit better overhead accuracy and increased force production during throws, highlighting the importance of targeted shoulder conditioning. Despite extensive research on hand grip and shoulder strength individually, there is limited evidence examining the combined effect of a structured hand grip and shoulder strengthening programme on functional performance in athletes. Most existing studies focus on one aspect in isolation, often neglecting the potential synergistic effects of training both distal and proximal muscle groups simultaneously. Integrating grip and shoulder strengthening may provide a comprehensive approach that enhances both force production and neuromuscular coordination across the upper limb, optimizing performance outcomes (Alzahrani et al., 2026.

Functional performance in sports encompasses not only strength but also coordination, stability, precision, and endurance. The interplay between hand grip and shoulder muscles is particularly significant in sports that require fine motor control under load or during complex dynamic actions. By improving both hand grip and shoulder strength, athletes may achieve enhanced control, accuracy, and overall movement efficiency, leading to measurable improvements in sport-specific performance (Cho et al., 2025). Moreover, strengthening these muscles can reduce injury risk by improving joint stability and load distribution, which is critical in both competitive and recreational athletic populations.

The rationale for this study is therefore twofold: first, to determine the efficacy of a combined hand grip and shoulder strengthening programme on measurable improvements in strength; and second, to evaluate whether these strength gains translate into enhanced functional performance in athletes engaged in sports requiring high upper limb engagement. The primary hypothesis is that athletes participating in an 8-week structured strengthening programme will demonstrate significant improvements in both hand grip and shoulder strength (Dcosta et al., 2025. The secondary hypothesis is that these gains in strength will be positively associated with improvements in functional performance metrics, including accuracy, stability, and task execution in sport-specific activities.

The findings of this study have important implications for sports coaching, strength and conditioning programmes, and physiotherapy interventions. By providing evidence for the benefits of integrated upper limb training, coaches and therapists can design more effective conditioning protocols that enhance performance while reducing the risk of upper limb injuries (Lee at al., 2025). Additionally, the study addresses a gap in the literature by examining the combined impact of distal (hand) and proximal (shoulder) strength training, offering insights for both athletic development and rehabilitation strategies.

2. Literature Review

2.1 Hand Grip Strength and Athletic Performance

Hand grip strength (HGS) is a widely used indicator of upper limb muscular capacity and overall neuromuscular performance. It reflects the integrated function of intrinsic and extrinsic hand muscles as well as forearm flexors, making it a practical and reliable measure for athletic profiling and physical assessment. Research in healthy populations suggests that strength-focused hand training can produce meaningful gains in HGS and manual dexterity, which are crucial for sport-specific tasks requiring controlled force application and fine motor control (Hasan et al., 2020). Systematic investigations reveal that targeted strength protocols significantly improve grip force, although the magnitude of improvement may vary across age groups and training modalities. Notably, strength-only protocols produced larger improvements in HGS compared to combined strength and proprioceptive interventions, although the difference was not statistically significant, indicating that strength training remains the most consistently effective approach for increasing HGS (Dcosta et al., 2025).

Athletes participating in upper body–dominant sports (e.g., combat sports, rowing, ball sports) tend to demonstrate greater HGS compared to those engaged in lower-body dominant activities, reflecting sport-specific adaptations from repetitive upper limb loading. A large cross-sectional study showed that individuals involved in sports with significant upper limb demands (such as kendo and baseball) presented notably higher HGS than participants in sports with minimal upper limb involvement (e.g., soccer), underscoring the influence of habitual activity on grip strength adaptation (Szaflik et al., 2025). Moreover, HGS has been linked to performance outcomes such as power generation, precision tasks, and movement stabilization in athletic contexts. Research on elite judo athletes revealed that medallists exhibit significantly higher static and dynamic hand grip strength than non-medallists, suggesting a strong association between grip force and competitive success in grappling and contact sports (Hasan et al., 2024). Despite its practical utility, some studies argue that HGS should not be the sole assessment of overall strength due to variability across test methods and its modest association with non-hand related muscle groups. A recent systematic review highlighted that while HGS correlates with strength measures in larger muscle groups, the strength association varies, emphasizing the need for comprehensive assessments that incorporate other strength metrics alongside HGS (Kaczorowska et al., 2025).

2.2 Shoulder Strength in Athletic Function

Shoulder muscle strength encompassing rotator cuff muscles, deltoid groups, and periscapular stabilizers is fundamental to performance across many sports, particularly those with overhead actions or rapid force transference. Elastic resistance training, plyometric exercises, and sport-specific conditioning have all been shown to enhance shoulder strength and associated performance outcomes, such as throwing velocity, overhead accuracy, and joint stability.

Shoulder strengthening interventions are frequently included in athletic conditioning to improve functional capacity and reduce injury risk. For example, resistance training protocols have demonstrated increases in isometric and dynamic shoulder muscle strength, contributing to enhanced performance in sports requiring powerful shoulder actions. Systematic evidence supporting elastic resistance programmes shows that properly structured shoulder training yields positive effects on muscle strength and functional outcomes, reinforcing its inclusion in sport training regimens (Do et al., 2025).

Recent trends in strength training explore innovative modalities such as blood flow restriction training (BFRT) to augment muscular adaptations. A 2025 meta-analysis reported that BFRT produces moderate to large improvements in shoulder flexion and internal rotation strength, although evidence quality was limited and effects on other shoulder motions (e.g., abduction, external rotation) were modest. These findings highlight that specialized interventions can enhance shoulder strength but must be carefully targeted to specific movement patterns relevant to athletic demands (Szaflik et al., 2025). Functional training approaches, which combine multi-joint strength exercises with sport-specific movements, also appear beneficial for improving broader physical and technical performance in athletes. A 2025 systematic review concluded that functional training significantly enhances physical performance indicators — including strength measures — across various sports. Although this research does not isolate shoulder outcomes, it reinforces the general principle that integrated strength programmes can improve athletic function when designed to reflect sport-relevant movement patterns (Bohannon, 2019).

2.3 Neuromuscular Interactions: Grip and Shoulder Dynamics

The interrelationship between hand grip and shoulder function has gained interest, especially in understanding how strength adaptations in one region may influence another. Early research demonstrated a strong correlation between grip strength and shoulder lateral rotator strength, suggesting that HGS assessments could provide insight into shoulder muscle recruitment and functional readiness. Additionally, grip force modulation has been linked with altered muscle activation patterns in the shoulder complex, illustrating neuromuscular connectivity between distal and proximal segments of the upper limb (Lee et al., 2025). Clinical evidence further supports this interaction. In individuals with shoulder impingement, incorporating hand grip-strengthening exercises into rehabilitation programs resulted in improved shoulder function, pain reduction, and increased rotator cuff muscle strength beyond conventional treatment alone. Such outcomes indicate that grip training can influence shoulder musculature indirectly, potentially through enhanced co-activation and neuromuscular modulation across joints (Kaczorowska et al., 2025). This interconnectedness underscores the rationale for integrated training programmes in athletes: strengthening both hand grip and shoulder muscles may yield synergistic effects on upper limb performance, particularly in tasks requiring coordinated force generation and stability. However, despite these associations, direct evidence on combined interventions in athletic populations remains limited, indicating a valuable gap in the current literature.

2.4 Functional Performance Outcomes Related to Strength Training

Strength training in athletes aims not only to increase isolated muscle force but also to enhance functional performance the ability to apply strength in sport-specific contexts. Functional performance outcomes include measures such as throwing accuracy, overhead stability, agility, and task execution speed, which require both strength and neuromuscular coordination.

Systematic evidence in broader strength and conditioning research confirms that well-designed resistance training improves technical and physical performance across athletic populations. Functional training, which integrates strength, stability, and movement coordination, was shown to significantly enhance physical performance and technical skills in athletes from diverse sports disciplines. These improvements suggest that strength training can generalize to complex sport tasks when programmes are appropriately structured to mirror sport-specific demands (Alzahrani et al., 2026).

In climbing and strength training contexts, combined programmes over short durations (e.g., six weeks) have produced significant improvements in grip strength and upper limb muscle morphology, indicating that targeted strength interventions can yield rapid benefits even in recreational athletes. Overall, the literature indicates robust associations between upper limb strength (both grip and shoulder) and various measures of athletic performance (Vinod et al., 2026). However, there remains a clear need for high-quality research examining combined hand grip and shoulder strength training specifically in athletic populations and assessing its direct impact on functional performance outcomes. This gap motivates the current study, which seeks to build on existing evidence by evaluating an integrated strengthening programme and its translation to sport-specific performance enhancements.

3. Methodology

3.1 Study Design

This study employed a quasi-experimental pre-post intervention design to examine the effects of an integrated hand grip and shoulder muscle strengthening programme on upper limb strength and functional performance in athletes. A pre-post design was selected to allow within-subject comparisons, enabling the measurement of changes attributable to the intervention while controlling for inter-individual variability. This design is consistent with previous rehabilitation and sports performance studies where randomized control trials were not feasible due to participant availability or ethical considerations.

3.2 Participants

A total of 28 competitive athletes (15 males, 13 females) aged 18–30 years were recruited from local sports clubs and university athletic teams. Participants represented sports with significant upper limb involvement, including tennis, volleyball, basketball, rowing, archery, and weightlifting. Recruitment was performed through advertisements in sports facilities, team notices, and social media platforms targeting athletes meeting inclusion criteria.

Inclusion criteria were:

- Age between 18 and 30 years
- At least two years of continuous competitive training
- Active participation in sports requiring upper limb strength or precision
- Baseline functional performance within normative ranges for their sport

Exclusion criteria were:

- Current upper limb or shoulder injury within the past six months
- History of upper limb surgery or chronic musculoskeletal disorders
- Participation in other structured upper limb strength programmes during the study period
- Neurological conditions affecting upper limb function

Participants provided written informed consent prior to enrolment. The study protocol was approved by the Institutional Ethics Committee, ensuring compliance with the Declaration of Helsinki for human research.

3.3 Sample Size Calculation

Sample size was determined using G*Power 3.1 software, with the parameters set for a paired t-test (two-tailed), an alpha level of 0.05, a power of 0.80, and an expected effect size of 0.65 based on similar interventions in upper limb strength research. The calculation indicated that a minimum of 25 participants were required. Accounting for potential dropouts (~10%), a total of 28 athletes were enrolled.

3.4 Intervention Protocol

The 8-week intervention programme was designed to target both hand grip and shoulder musculature to enhance strength, stability, and functional performance. Participants completed three sessions per week, each lasting approximately 45–60 minutes. Each session included warm-up, strengthening exercises, functional drills, and cool-down routines.

3.4.1 Hand Grip Strengthening

Hand grip exercises focused on improving maximal voluntary contraction, endurance, and finger coordination:

1. **Hand Dynamometer Squeezes:** Participants performed three sets of 15 maximal squeezes with each hand, holding each contraction for 3 seconds with 30-second rest intervals.
2. **Resistance Band Finger Extensions:** Three sets of 12 repetitions were performed per hand to strengthen finger extensors and forearm stabilizers.
3. **Stress Ball Holds:** Athletes performed three sets of 15 progressive resistance ball squeezes, holding for 5 seconds each, to improve sustained grip endurance.

3.4.2 Shoulder Muscle Strengthening

Shoulder exercises targeted primary movers and stabilizers, emphasizing rotator cuff activation, deltoid recruitment, and scapular stability:

1. **Dumbbell Shoulder Presses:** 3 sets of 10 repetitions with moderate weight, focusing on controlled upward and downward motion.
2. **Lateral Resistance Band Raises:** 3 sets of 12 repetitions to strengthen middle deltoids and shoulder abductors.
3. **Rotator Cuff Internal/External Rotation:** 3 sets of 15 repetitions using resistance bands to target rotator cuff muscles.
4. **Closed Kinetic Chain Stability Drills:** 3 sets of 10 repetitions, including push-up plus and plank variations, to enhance scapular stabilization and proximal control.

Progression: Resistance or repetitions were increased every two weeks to maintain progressive overload. Sessions were supervised by a licensed physiotherapist to ensure correct form and minimize injury risk.

3.4.3 Warm-up and Cool-down

Each session began with a 10-minute warm-up including dynamic stretches, shoulder circles, and light grip activations. Sessions concluded with a 5–10-minute cool-down consisting of static stretching, deep breathing, and mobility exercises to facilitate recovery.

3.5 Outcome Measures

3.5.1 Hand Grip Strength

HGS was assessed using a calibrated hand dynamometer (Jamar®). Participants performed three maximal voluntary contractions per hand, with a 60-second rest between trials. The highest value of the three trials was recorded. Reliability for HGS measurement in adults is reported to be excellent (ICC = 0.95).

3.5.2 Shoulder Strength

Isometric shoulder strength was measured using a hand-held dynamometer (MicroFET2) in three **motions:** flexion, abduction, and external rotation. Participants were instructed to gradually reach maximal contraction over 3 seconds, holding for 5 seconds. Three trials per motion were recorded, with the highest value used for analysis.

3.5.3 Functional Performance Tests

Sport-specific functional performance tests were selected based on participant sport requirements, including:

1. **Throwing Accuracy Test:** Number of successful hits within a designated target zone in a set of 10 throws.
2. **Overhead Stability Control Test:** Duration participants could maintain a controlled overhead arm position against light resistance.
3. **Task Execution Speed:** Time to complete an upper limb–dominant sport-specific drill (e.g., passing a ball, racket swing, or rowing stroke sequence).

All tests were conducted pre- and post-intervention under standardized conditions, with participants instructed and supervised to ensure consistency.

3.6 Data Analysis

Data were analysed using SPSS v28.0. Normality was assessed via the Shapiro-Wilk test. Paired sample t-tests compared pre- and post-intervention outcomes. Effect sizes (Cohen's d) were calculated to determine the magnitude of intervention effects. Pearson correlation coefficients evaluated the relationship between strength improvements and functional performance gains. Statistical significance was set at $p < 0.05$.

4. Results

4.1 Participant Demographics

A total of 28 athletes completed the 8-week intervention (15 males, 13 females). The mean age was 22.8 ± 3.1 years, with an average of 4.2 ± 1.5 years of competitive training experience. The distribution of sports included: tennis (n = 7), volleyball (n = 6), basketball (n = 5), rowing (n = 4), archery (n = 3), and weightlifting (n = 3). No participants reported adverse events, and adherence to the training programme was 100%.

Table 1. Participant Demographics

Variable	Total (n=28)	Male (n=15)	Female (n=13)
Age (years)	22.8 ± 3.1	23.1 ± 3.2	22.4 ± 3.0
Training Experience (years)	4.2 ± 1.5	4.3 ± 1.6	4.0 ± 1.5
Sport			
– Tennis	7	4	3
– Volleyball	6	3	3
– Basketball	5	3	2
– Rowing	4	2	2
– Archery	3	1	2
– Weightlifting	3	2	1

4.2 Hand Grip Strength Outcomes

Post-intervention analysis revealed a significant increase in hand grip strength for both hands. Pre-intervention mean grip strength for the dominant hand was 42.5 ± 5.8 kg, increasing to 48.3 ± 6.2 kg post-intervention (p < 0.001, Cohen's d = 0.96). For the non-dominant hand, pre-intervention mean was 39.7 ± 5.3 kg, improving to 44.8 ± 5.7 kg (p < 0.001, Cohen's d = 0.91). These results indicate a moderate-to-large effect of the intervention on grip strength.

Table 1. Pre- and Post-Intervention Hand Grip Strength

Hand	Pre-intervention (kg)	Post-intervention (kg)	p-value	Cohen's d
Dominant	42.5 ± 5.8	48.3 ± 6.2	<0.001	0.96
Non-dominant	39.7 ± 5.3	44.8 ± 5.7	<0.001	0.91

4.3 Shoulder Strength Outcomes

Isometric shoulder strength increased across all assessed motions: flexion, abduction, and external rotation. Mean pre-intervention flexion strength was 32.1 ± 4.6 kg, increasing to 37.5 ± 5.1 kg post-intervention (p < 0.001). Abduction improved from 30.4 ± 4.3 kg to 35.6 ± 4.9 kg (p < 0.001), and external rotation from 22.8 ± 3.7 kg to 27.9 ± 4.2 kg (p < 0.001). Effect sizes were large across all measures (Cohen's d = 0.92–1.05), demonstrating substantial improvements in shoulder strength following the intervention.

Table 2. Pre- and Post-Intervention Shoulder Strength

Motion	Pre-intervention (kg)	Post-intervention (kg)	p-value	Cohen's d
Flexion	32.1 ± 4.6	37.5 ± 5.1	<0.001	1.02
Abduction	30.4 ± 4.3	35.6 ± 4.9	<0.001	0.97
External Rotation	22.8 ± 3.7	27.9 ± 4.2	<0.001	0.92

4.4 Functional Performance Outcomes

Functional performance was assessed using sport-specific tests including throwing accuracy, overhead stability, and task execution speed.

- Throwing Accuracy: Pre-intervention mean score was 6.3 ± 1.2 out of 10, increasing to 8.2 ± 0.9 post-intervention (p < 0.001, Cohen's d = 1.78).
- Overhead Stability: Pre-intervention mean duration maintained was 12.4 ± 3.1 seconds, increasing to 18.5 ± 3.6 seconds post-intervention (p < 0.001, Cohen's d = 1.74).
- Task Execution Speed: Pre-intervention mean completion time was 15.2 ± 2.7 seconds, decreasing to 12.6 ± 2.3 seconds

post-intervention ($p < 0.001$, Cohen's d = 1.00).

These improvements suggest that strength gains translated effectively into functional enhancements relevant to athletic performance.

Table 3. Pre- and Post-Intervention Functional Performance

Test	Pre-intervention	Post-intervention	p-value	Cohen's d
Throwing Accuracy (score/10)	6.3 ± 1.2	8.2 ± 0.9	<0.001	1.78
Overhead Stability (seconds)	12.4 ± 3.1	18.5 ± 3.6	<0.001	1.74
Task Execution Speed (seconds)	15.2 ± 2.7	12.6 ± 2.3	<0.001	1.00

4.5 Correlation Between Strength Gains and Functional Performance

Pearson correlation analysis demonstrated **moderate-to-strong positive correlations** between improvements in strength and functional performance metrics:

- Dominant hand grip vs throwing accuracy: $r = 0.68$, $p < 0.01$
- Shoulder abduction strength vs overhead stability: $r = 0.71$, $p < 0.01$
- Combined grip and shoulder strength vs task execution speed: $r = -0.63$, $p < 0.01$ (negative correlation indicates faster completion with higher strength)

These correlations indicate that participants who gained the most in grip and shoulder strength tended to perform better on sport-specific functional tasks.

Table 5. Correlation Between Strength Gains and Functional Performance

Variables	Throwing Accuracy	Overhead Stability	Task Execution Speed
Dominant Hand Grip	r = 0.68**	r = 0.62**	r = –0.55**
Non-dominant Hand Grip	r = 0.61**	r = 0.59**	r = –0.50**
Shoulder Flexion	r = 0.65**	r = 0.70**	r = –0.60**
Shoulder Abduction	r = 0.66**	r = 0.71**	r = –0.63**
Shoulder External Rotation	r = 0.60**	r = 0.65**	r = –0.57**

The 8-week hand grip and shoulder strengthening programme led to significant gains in grip and shoulder strength, which translated into improved functional performance. Strong correlations suggest that athletes with greater strength improvements demonstrated better accuracy, stability, and task execution speed. The intervention showed moderate-to-large effect sizes across all outcomes, highlighting its practical relevance for sports performance enhancement.

5. Discussion

The present study investigated the impact of an 8-week hand grip and shoulder muscle strengthening programme on functional performance in athletes. The results demonstrate significant improvements in hand grip strength, shoulder strength, and sport-specific functional performance, confirming that a combined upper limb strengthening protocol can produce meaningful enhancements in athletic performance. This discussion interprets these findings in light of previous research, explores underlying mechanisms, and highlights practical applications for athletic conditioning and rehabilitation.

5.1 Improvements in Hand Grip Strength

The study revealed a significant increase in hand grip strength for both dominant and non-dominant hands, with a 14% improvement for the dominant hand and 13% for the non-dominant hand. These results align with prior research indicating that progressive resistance training, even over relatively short durations (6–8 weeks), can produce substantial gains in grip strength (Aydın & Bas, 2023; Bohannon, 2019). The improvement in the non-dominant hand also underscores the value of symmetrical training and suggests that bilateral exercises can enhance neuromuscular recruitment patterns across both limbs.

Hand grip strength is functionally important for athletes involved in sports requiring precision, sustained force application, and object control. Increased grip strength contributes to better control over sports implements such as balls, racquets, and oars, and supports stability in contact or overhead sports. The findings of this study confirm that structured grip exercises — including dynamometer squeezes, resistance band extensions, and stress ball holds — are effective in enhancing maximal voluntary contraction and grip endurance (Cho et al., 2025).

Electromyographic studies support the concept that grip strength improvements may indirectly influence proximal upper limb musculature. Co-activation of shoulder stabilizers during gripping tasks suggests that improved hand grip may enhance shoulder stabilization and functional performance during dynamic movements (Karasheva et al., 2025). Therefore, grip strength gains observed in this study likely contributed to improved functional outcomes observed in overhead stability and task execution.

5.2 Shoulder Strength Gains and Functional Implications

Significant improvements were observed in all measures of shoulder strength — flexion, abduction, and external rotation. These findings are consistent with prior research demonstrating that resistance training targeting the rotator cuff, deltoids, and scapular stabilizers increases isometric and dynamic shoulder strength in both recreational and competitive athletes (Dcosta et al., 2024; Reyhani et al., 2024).

Shoulder strength is crucial for force transmission, joint stabilization, and precision in upper limb tasks. Improved shoulder strength supports more efficient kinetic chain function, allowing athletes to generate and control force in a coordinated manner. In overhead sports such as tennis or volleyball, stronger shoulder stabilizers reduce compensatory motions and decrease the risk of overuse injuries. Additionally, strength improvements in external rotation contribute to enhanced rotator cuff function, which is critical for joint integrity and injury prevention.

The observed shoulder strength gains are likely due to the combination of progressive overload and multi-directional exercises. The intervention included both open kinetic chain movements (e.g., dumbbell presses, resistance band raises) and closed kinetic chain stability drills (e.g., push-up plus, plank variations), which are known to activate both prime movers and stabilizers. This combination promotes hypertrophy, neuromuscular recruitment, and functional strength, explaining the substantial gains observed in this study.

5.3 Functional Performance Enhancements

Functional performance improvements were reflected in throwing accuracy, overhead stability, and task execution speed. Throwing accuracy improved by ~30%, overhead stability by ~49%, and task execution speed improved by ~17%. These results demonstrate that strength gains were not isolated to raw force but translated into sport-specific performance improvements, supporting the ecological validity of the training programme.

The positive correlations between grip and shoulder strength gains with functional outcomes (r = 0.60–0.71) indicate that athletes with the greatest strength improvements also showed the largest functional gains. This is consistent with literature suggesting that upper limb strength is a strong predictor of task performance in sports requiring precision, stability, and force control (Bohannon, 2019; Bobos et al., 2020).

From a physiological perspective, enhanced functional performance can be attributed to neuromuscular adaptations, including increased motor unit recruitment, improved inter-muscular coordination, and optimized muscle firing patterns. Strengthening distal (grip) and proximal (shoulder) musculature concurrently likely improved kinetic chain efficiency, allowing force generated in the forearm and hand to be transmitted effectively through the shoulder and into sport-specific actions.

5.4 Mechanisms Underlying Combined Grip and Shoulder Training

The synergistic effect of combined hand grip and shoulder training is supported by evidence of neuromuscular interdependence between distal and proximal segments of the upper limb. EMG studies indicate that gripping activates shoulder stabilizers, particularly during elevated arm positions, enhancing shoulder co-contraction and joint stability (Do et al., 2025). By simultaneously training hand and shoulder muscles, the programme likely reinforced proximal-distal coordination, improving both force generation and motor control.

Additionally, closed kinetic chain exercises targeting the shoulder may have facilitated joint proprioception and dynamic stabilization, further contributing to functional performance gains. These mechanisms provide a physiological explanation for the strong correlations observed between strength improvements and functional outcomes in this study.

6. Practical Implications for Athletes and Rehabilitation

The findings have important applications in athletic training and rehabilitation. Coaches and physiotherapists can incorporate combined grip and shoulder strengthening programmes to enhance performance in sports requiring upper limb precision, force control, and stability. The intervention's short duration (8 weeks) and moderate frequency (3 sessions/week) demonstrate that meaningful strength and functional gains can be achieved without excessive training load, making it suitable for both competitive athletes and recreational players.

In rehabilitation settings, integrating hand grip and shoulder strengthening may accelerate recovery for athletes returning from upper limb injuries, improve joint stability, and reduce the risk of future injuries. Moreover, bilateral training can ensure symmetrical development, which is critical for injury prevention and functional balance in sports involving repetitive unilateral movements.

7. Limitations

Despite the positive findings, this study has limitations. The sample size was relatively small and heterogeneous, including athletes from multiple sports, which may limit generalizability to specific sports. The absence of a control group prevents definitive causal conclusions, although pre-post design and significant effect sizes provide strong evidence for the intervention's efficacy. Additionally, long-term retention of strength and functional improvements was not assessed, leaving questions about sustainability.

8. Future Research Directions

Future studies should consider randomized controlled trials with sport-specific cohorts to confirm these findings. Investigating long-term retention of strength and functional gains, as well as integrating periodization strategies and sport-specific drills, could further optimize upper limb training programmes. Exploring neuromuscular adaptations using EMG or motion capture could also provide deeper insights into the mechanisms underlying performance improvements.

9. Conclusion

The present study demonstrates that an integrated hand grip and shoulder strengthening programme significantly improves both upper limb strength and sport-specific functional performance in athletes. These findings highlight the importance of combined distal and proximal training for enhancing athletic performance, reducing injury risk, and improving neuromuscular coordination. The strong correlation between strength gains and functional improvements suggests that athletes who maximize grip and shoulder strength will likely experience the greatest benefits in precision, stability, and task execution.

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