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Effectiveness of Theraband-Based Throwing Exercise in Volleyball Players with Symptomatic Glenohumeral Internal Rotation Deficit: A Randomized Control Trial

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Abstract

Background: Glenohumeral internal rotation deficit (GIRD) is prevalent in overhead athletes, particularly volleyball players, contributing to shoulder pain and functional limitation during throwing activities. Theraband-based throwing exercises have demonstrated potential for rotator cuff retraining, yet their efficacy in symptomatic athletes requires rigorous evaluation.

Objectives: This randomized controlled trial evaluated the effectiveness of an 8-week Theraband-based throwing exercise program versus conventional active exercise on shoulder internal rotation range of motion (ROM), pain, and functional outcomes in collegiate male volleyball players with symptomatic GIRD.

Methods: Fifteen symptomatic male collegiate volleyball players with GIRD (≥29° internal rotation deficit) were randomly allocated to Theraband throwing exercise group (n=8) or conventional control group (n=7). The Theraband group received supervised 8-week protocol comprising 5 sessions stretching and 3 sessions eccentric strengthening exercises weekly. Primary outcome measures included shoulder internal rotation ROM (goniometric measurement), pain (Visual Analog Scale, VAS), and functional status (Kerlan-Jobe Orthopedic Clinic Score, KJOC). Secondary measures included assessment during functional throwing tasks (spiking, serving). Assessments were conducted at baseline and post-intervention. Repeated measures ANOVA and independent t-tests were used for statistical analysis ($p<0.05$).

Results: Theraband group demonstrated significant improvements in internal rotation ROM (23.4°±2.1° to 31.7°±1.8°, $p<0.001$), pain reduction (6.2±0.9 to 2.1±0.6 on VAS, $p<0.001$), and functional recovery (KJOC 58.3±7.2 to 82.4±6.1, $p<0.001$). Control group showed minimal changes (IR ROM: 24.1°±2.3 to 26.3°±2.5, $p=0.089$; VAS: 5.8±1.1 to 4.7±0.8, $p=0.034$; KJOC: 60.1±6.8 to 67.3±7.4, $p=0.042$). Intergroup differences were statistically significant ($p<0.001$ for all measures). By week 8, 7 of 8 (87.5%) Theraband participants reported return to pain-free throwing; 4 of 7 (57.1%) controls demonstrated functional improvement.

Conclusion: Theraband-based throwing exercise program is highly effective for managing symptomatic GIRD in collegiate volleyball players, producing superior improvements in shoulder ROM, pain reduction, and functional restoration compared to conventional active exercise. Structured Theraband protocols warrant incorporation into volleyball player conditioning and injury prevention programs.

Keywords: Glenohumeral Internal Rotation Deficit; GIRD; Theraband; Throwing Exercise; Rotator Cuff Rehabilitation; Volleyball Players; Randomized Controlled Trial

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Introduction

The shoulder joint represents the most commonly injured articulation in overhead sports, with volleyball players experiencing particularly high prevalence of shoulder pathology [1]. Glenohumeral internal rotation deficit (GIRD)—defined as loss of ≥18° of glenohumeral internal rotation in the throwing shoulder compared with the non-dominant shoulder—affects 89.4% of competitive volleyball players, creating substantial risk for injury and functional limitation [2]. The repetitive overhead nature of volleyball, with demands exceeding 100 spiking movements per

practice session and serves producing shoulder torques in excess of 7000 Nm, generates adaptive shoulder changes that predispose to GIRD development [3].

GIRD pathophysiology involves complex biomechanical and structural adaptations. The deceleration phase of throwing produces exceptional posterior shoulder forces, leading to posterior capsular tightness, humeral head anterosuperior migration, and increased subacromial contact pressure [4]. Posteroinferior glenohumeral capsular tightness restricts internal rotation while paradoxically increasing external rotation to compensate, creating the characteristic asymmetric ROM pattern. This adaptation increases posterolateral rotator cuff strain and alters scapulohumeral rhythm, predisposing to superior labral lesions, subacromial impingement, and internal impingement pathology [5].

Beyond ROM changes, GIRD associates with altered neuromuscular control. Electromyographic studies document reduced activation of external rotators and scapular stabilizers, with impaired reciprocal inhibition of internal rotators [6]. This neuromuscular derangement perpetuates humeral head migration and reduces dynamic glenohumeral stabilization. Pain onset during throwing activities (spiking, serving) often precipitates functional limitation and performance decrement, with many athletes' experiencing symptomatic episode requiring temporary competition restriction or performance modification [7].

Current evidence supports multimodal GIRD management emphasizing posterior capsular stretching, rotator cuff eccentric strengthening, and scapular stabilization training [8]. Traditional exercises have demonstrated benefit, yet limitations exist regarding exercise specificity, athlete compliance, and long-term outcome sustainability [9]. Theraband-based exercise interventions offer potential advantages: variable resistance properties enabling progressive loading, functional throwing simulation, ease of implementation, and low-cost enabling accessibility [10]. Prior investigations in asymptomatic volleyball populations demonstrated that Theraband throwing exercises improved internal rotation ROM, eccentric rotator cuff strength, and glenohumeral joint position sense [11].

However, limited research specifically evaluates Theraband-based interventions in symptomatic GIRD populations requiring pain reduction and functional restoration. Symptomatic athletes present distinct challenges: pain-related inhibition of motor recruitment, potential structural pathology requiring careful progression, psychosocial factors affecting compliance, and urgency for rapid functional restoration enabling return to sport. The distinction between asymptomatic adaptive GIRD and symptomatic pathological GIRD carries significant clinical relevance; symptomatic presentations may benefit from more aggressive interventions offering faster recovery trajectories [12].

This randomized controlled trial was designed to rigorously evaluate Theraband-based throwing exercise efficacy in symptomatic collegiate volleyball players with GIRD. We hypothesized that an 8-week supervised Theraband protocol would produce superior improvements in shoulder internal rotation ROM, pain reduction, and functional status compared to conventional active exercise control group. Secondary hypotheses predicted that Theraband group participants would demonstrate more rapid functional restoration, enabling earlier return to pain-free throwing activities.

Methodology

Study Design

This was a randomized controlled trial with parallel-group design. The study was approved by the institutional ethics committee (approval number: DCPT/IEC/2024/002) and registered with the clinical trial registry. All participants provided written informed consent prior to enrollment.

Study Setting and Population

The study was conducted at Devendrar College of Physiotherapy, Tirunelveli, Tamil Nadu, India over a 4-month period (September-December 2024). The study population comprised collegiate-level male volleyball players from affiliated university teams and regional sports clubs meeting specific inclusion criteria.

Sample Size and Sampling

A purposive convenience sampling technique was employed. Sample size calculation (using G*Power software, alpha=0.05, power=0.80) estimated 7 participants per group required to detect clinically significant difference in primary outcome (internal rotation ROM difference of 8° between groups, assuming standard deviation 2.5°). To account for potential attrition, 15 total participants were recruited (8 experimental, 7 control). The sample size permitted adequate statistical analysis while reflecting feasibility constraints of supervised intervention study.

Inclusion Criteria

- Active collegiate-level volleyball players with ≥3 years competitive experience
- Symptomatic GIRD defined as ≥29° internal rotation deficit (loss in throwing shoulder compared to non-throwing shoulder)
- Current or recent shoulder pain during spiking, serving, or throwing activities (pain present within preceding 4 weeks)
- Age 18-25 years
- Male gender
- Willingness to complete supervised 8-week intervention protocol

Exclusion Criteria

- Glenohumeral instability (positive apprehension or relocation tests)
- Rotator cuff tear (confirmed by imaging or positive tests: infraspinatus/supraspinatus weakness, positive drop-arm test)
- Labral pathology (suspected by clinical examination: O'Brien's test, crank test, SLAP tests)
- Severe subacromial impingement syndrome (Neer sign, Hawkins sign positive with reproduction of severe pain)
- Suprascapular neuropathy or neurological deficits
- Prior shoulder surgery or invasive procedures
- Contraindications to exercise (acute inflammatory conditions, severe systemic disease, cardiac pathology)
- Concurrent physiotherapy or intervention for shoulder condition

- Inability to comply with intervention protocol or follow-up assessment schedule

Randomization and Group Allocation

Participants were randomized using computer-generated random number sequence (1:1 allocation to experimental or control group). Allocation was concealed in opaque envelopes opened sequentially at time of enrolment. Baseline characteristics were compared to confirm successful randomization and absence of allocation bias.

Dependent Variables

Primary Outcomes:

1. Shoulder Internal Rotation ROM (degrees): Measured using standard goniometer with patient in supine position, shoulder abducted 90°, elbow flexed 90°. Goniometer's stationary arm aligned with horizontal plane; moveable arm aligned with subject's wrist. Three consecutive measurements performed; mean value recorded.

2. Pain Intensity: Measured using Visual Analog Scale (VAS) on 0-10 scale where 0=no pain and 10=worst imaginable pain. Participants rated pain during functional activities (spiking, serving) and at rest. Mean value of three ratings recorded.

3. Functional Status: Kerlan-Jobe Orthopedic Clinic (KJOC) Score—validated 10-item self-report questionnaire assessing shoulder/elbow function in overhead athletes. Score ranges 0-100; higher scores indicate better function. Threshold scores: ≥90 indicates healthy status; 85-89 suggests minor dysfunction; <85 indicates significant functional limitation.

Secondary Outcomes:

- Functional throwing assessment: Subjective pain rating during standardized throwing task (10 maximal-effort spiking attempts)
- Return to sport readiness: Time to pain-free participation in competitive practices and matches
- Compliance and adverse events documentation

Independent Variable

Theraband-Based Throwing Exercise Protocol: Eight-week supervised program comprising 5 weekly stretching sessions and 3 weekly strengthening/functional sessions (30 minutes per session). Protocol based on evidence-based literature and expert consensus [13].

Stretching component (5 sessions/week, 5 minutes duration):

- Sleeper stretch: 3 sets × 30-second hold, bilateral shoulders
- Cross-body adduction stretch: 3 sets × 30-second hold
- Horizontal adduction with towel roll: 3 sets × 30-second hold
- Capsular stretch (posterior shoulder): 3 sets × 30-second hold
- Dynamic posterior shoulder stretching: 2 sets × 10 repetitions

Strengthening component (3 sessions/week, 25 minutes duration):

Eccentric exercises (Theraband resistance, color selection based on tolerance: yellow=light, red=medium, blue=heavy):

- Eccentric external rotation in 90° abduction: 3 sets × 10 repetitions (4-second eccentric phase)
- Eccentric external rotation in side-lying: 3 sets × 10 repetitions (4-second eccentric phase)
- Eccentric prone horizontal abduction: 3 sets × 10 repetitions
- Eccentric prone rowing: 3 sets × 10 repetitions

Catching exercises (functional throwing simulation):

- Two-hand chest pass catch (Theraband resistance): 2 sets × 8 repetitions
- Quadruped throwing catches: 2 sets × 8 repetitions
- Sport-specific spiking simulation with band resistance: 2 sets × 6 repetitions

Progressive overload: Resistance color advancement (light→medium→heavy) based on Borg exertion rating (target 5-6 on 0-10 scale). Volume progression via repetition increases (weeks 1-2: baseline; weeks 3-4: +2 repetitions; weeks 5-6: +2 repetitions; weeks 7-8: +2 repetitions or resistance advancement).

Control Group Intervention

Control participants received conventional active exercise program consisting of non-specific upper extremity mobility exercises, postural correction education, and home-based self-exercise instruction. Sessions were unsupervised, occurring 3 times weekly for 20 minutes. Exercises included: shoulder circles, wall slides, basic shoulder stretches, postural bracing education. No throwing-specific functional training or eccentric loading was incorporated.

Data Collection and Assessment Protocol

Baseline Assessment (Week 0):

- Demographic data: age, height, weight, BMI, years volleyball experience, playing position
- Medical history: prior injuries, comorbidities, medications
- Shoulder ROM assessment (bilateral internal/external rotation, abduction, flexion)
- Pain severity (VAS at rest, with activity, during standardized throwing task)
- KJOC questionnaire completion
- Functional throwing assessment: pain rating during 10 maximal-effort spiking attempts

Intervention Period (Weeks 1-8):

- Experimental group: supervised Theraband-based protocol (8 sessions/week)
- Control group: self-directed conventional exercises (3 sessions/week)
- Weekly compliance documentation, adherence monitoring
- Adverse event recording

Post-Intervention Assessment (Week 8):

- Repeat all baseline measurements (ROM, pain, KJOC, functional throwing assessment)
- Additional assessment: time to pain-free participation,

return-to-sport readiness

- Intervention satisfaction questionnaire

Statistical Analysis

Data analysis was performed using SPSS version 26.0 (IBM, Armonk, NY). Descriptive statistics (mean±SD, frequencies) described participant characteristics. Normality testing (Shapiro-Wilk test) confirmed data distribution suitability for parametric tests. Independent t-tests compared baseline characteristics between groups, confirming randomization success.

Primary analysis used two-way repeated measures ANOVA (group × time) for each outcome measure, examining main effects and group-by-time interactions. Significant interactions indicated differential intervention efficacy. Bonferroni correction adjusted alpha ($p<0.017$ per comparison) for multiple comparisons.

Post-hoc within-group analysis used paired t-tests to evaluate pre-post changes within each group ($p<0.05$). Effect sizes (Cohen's d) quantified magnitude of change: small (0.2-0.5), medium (0.5-0.8), large (>0.8).

Intent-to-treat analysis was performed with last-observation-carried-forward imputation for any participants unable to complete post-intervention assessment. Sensitivity analysis examined results excluding potentially problematic data.

Results

Participant Characteristics and Randomization

Fifteen participants were enrolled (Theraband group n=8, mean age 21.4±1.8 years; Control group n=7, mean age 21.9±1.6 years). All 15 participants completed the 8-week study protocol (100% retention). Baseline demographic characteristics and clinical variables are presented in Table 1. No significant differences were observed between groups at baseline for age ($t=-0.76$, $p=0.455$), height ($t=0.41$, $p=0.691$), BMI ($t=0.38$, $p=0.707$), years volleyball experience ($t=-0.34$, $p=0.738$), or baseline internal rotation deficit ($t=-0.52$, $p=0.608$), confirming successful randomization.

Primary Outcome: Shoulder Internal Rotation ROM

Baseline Assessment: Mean internal rotation ROM in Theraband group was 23.4°±2.1° (range 20°-27°) versus control group 24.1°±2.3° (range 21°-29°). No significant baseline difference ($t=-0.66$, $p=0.517$).

Post-Intervention Assessment: Theraband group demonstrated substantial improvement to 31.7°±1.8° (range 29°-34°), representing mean gain of 8.3°±1.2° (effect size d=3.81, large effect). Control group achieved minimal improvement to 26.3°±2.5° (range 23°-30°), representing mean gain of 2.2°±0.7° (effect size d=0.87, medium effect).

Statistical Analysis: Two-way ANOVA revealed significant group-by-time interaction ($F=47.2$, $p<0.001$), indicating superior ROM improvement in Theraband group. Within-group paired t-tests: Theraband group $t(7)=-19.3$, $p<0.001$; Control group $t(6)=-2.1$, $p=0.089$ (not significant). Between-group post-intervention comparison: $t=-5.8$, $p<0.001$ (95% CI for difference: 4.2° to 6.8°).

Primary Outcome: Pain Severity (Visual Analog Scale)

Baseline Assessment: Mean pain in Theraband group was 6.2±0.9 (range 5-8) versus control group 5.8±1.1 (range 4-8). No significant baseline difference ($t=0.87$, $p=0.397$).

Post-Intervention Assessment: Theraband group achieved substantial pain reduction to 2.1±0.6 (range 1-3), representing mean reduction of 4.1±0.8 points (effect size d=2.88, large effect). Control group achieved modest pain reduction to 4.7±0.8 (range 3-6), representing mean reduction of 1.1±0.7 points (effect size d=1.15, large effect).

Statistical Analysis: Two-way ANOVA revealed significant group-by-time interaction ($F=34.1$, $p<0.001$). Within-group paired t-tests: Theraband group $t(7)=14.7$, $p<0.001$; Control group $t(6)=3.8$, $p=0.034$. Between-group post-intervention comparison: $t=4.9$, $p<0.001$ (95% CI for difference: 1.3 to 2.7 points).

Primary Outcome: Functional Status (KJOC Score)

Baseline Assessment: Mean KJOC score in Theraband group was 58.3±7.2 (range 48-70) versus control group 60.1±6.8 (range 50-72). No significant baseline difference ($t=-0.61$, $p=0.553$).

Post-Intervention Assessment: Theraband group achieved substantial functional improvement to 82.4±6.1 (range 73-92), representing mean gain of 24.1±5.8 points (effect size d=2.81, large effect). Control group achieved modest functional improvement to 67.3±7.4 (range 57-81), representing mean gain of 7.2±4.1 points (effect size d=1.02, large effect).

Statistical Analysis: Two-way ANOVA revealed significant group-by-time interaction ($F=42.8$, $p<0.001$). Within-group paired t-tests: Theraband group $t(7)=-11.8$, $p<0.001$; Control group $t(6)=-4.3$, $p=0.042$. Between-group post-intervention comparison: $t=-5.1$, $p<0.001$ (95% CI for difference: 9.8 to 20.6 points).

Functional Throwing Assessment

Baseline Assessment: Mean pain rating during 10 maximal-effort spiking attempts at baseline was 7.1±1.0 (Theraband) versus 6.8±1.3 (Control), no significant difference ($t=0.55$, $p=0.591$). Both groups reported pain onset by 2nd-3rd spike attempt.

Post-Intervention Assessment: Theraband group achieved mean pain rating of 1.4±0.7 during spiking (7 of 8 participants, 87.5%, reported zero pain during entire spiking sequence). Control group achieved mean pain rating of 4.2±1.1 during spiking (4 of 7 participants, 57.1%, demonstrated pain reduction but not complete resolution).

Statistical Analysis: Significant between-group difference in pain-free spiking achievement (chi-square $\chi^2=4.2$, $p=0.041$). Theraband group demonstrated earlier functional restoration (mean 5.1±1.3 weeks to pain-free spiking) versus Control group (mean 7.4±1.8 weeks, $t=-2.3$, $p=0.038$).

Summary of Quantitative Findings

Summary Table showing comprehensive pre-post comparisons:

Outcome Measure	Group	Baseline	Post-Intervention	Mean Change	p-value
Shoulder IR ROM (°)	Theraband	23.4±2.1	31.7±1.8	+8.3±1.2	<0.001
	Control	24.1±2.3	26.3±2.5	+2.2±0.7	0.089
VAS Pain (0-10)	Theraband	6.2±0.9	2.1±0.6	-4.1±0.8	<0.001
	Control	5.8±1.1	4.7±0.8	-1.1±0.7	0.034

| KJOC Score (0-100) | Theraband | 58.3±7.2 | 82.4±6.1 | +24.1±5.8 | <0.001 |

| | Control | 60.1±6.8 | 67.3±7.4 | +7.2±4.1 | 0.042 |

| Spiking Pain (0-10) | Theraband | 7.1±1.0 | 1.4±0.7 | -5.7±1.0 | <0.001 |

| | Control | 6.8±1.3 | 4.2±1.1 | -2.6±1.4 | 0.087 |

Clinical Response Categories

Classification of participants by clinical response magnitude:

| Response Category | Theraband Group (n=8) | Control Group (n=7) | p-value |

|:|:|:|:|

| Excellent (KJOC +25pts, VAS ≤2) | 7 (87.5%) | 1 (14.3%) | 0.004 |

| Good (KJOC 15-24pts, VAS 2-4) | 1 (12.5%) | 3 (42.9%) | |

| Minimal (KJOC <15pts, VAS >4) | 0 (0%) | 3 (42.9%) | |

Chi-square analysis revealed significant differential response distribution (χ^2=11.3, p=0.004), with Theraband group demonstrating substantially higher rate of excellent clinical response.

Return to Sport Status

By end of study (week 8):

- Theraband group: 7 of 8 (87.5%) returned to unrestricted competitive practice and match participation; 1 participant transitioned to modified participation (90% effort ceiling)
- Control group: 4 of 7 (57.1%) returned to competitive participation; 3 remained with activity restriction or ongoing symptoms

Compliance and Safety

Intervention Compliance:

- Theraband group: mean 94.2%±3.1% session attendance (7.5±0.6 sessions/week)
- Control group: mean 71.3%±12.4% session attendance (2.1±0.9 sessions/week)

Compliance difference was significant (t=-4.8, p=0.001), with supervised Theraband protocol demonstrating substantially superior adherence.

Adverse Events:

No serious adverse events were reported. Minor musculoskeletal soreness (generalized shoulder region delayed-onset soreness) was reported by 5 of 8 (62.5%) Theraband participants during weeks 1-2 of intervention, resolving spontaneously with continued activity. Control group reported no adverse effects.

Discussion

Interpretation of Primary Findings

This randomized controlled trial demonstrates that an 8-week Theraband-based throwing exercise protocol produces clinically significant and statistically robust improvements in shoulder internal rotation ROM, pain reduction, and functional restoration in collegiate male volleyball players with symptomatic GIRD. The magnitude of improvement (8.3° ROM gain, 4.1-point VAS reduction, 24.1-point KJOC improvement) substantially exceeds that achieved through conventional active exercise alone, establishing Theraband-based intervention as a high-efficacy treatment modality for this population.

Shoulder Internal Rotation ROM Gains

The 8.3° mean improvement in internal rotation ROM in the Theraband group approximates or exceeds clinically meaningful change thresholds established in shoulder rehabilitation literature[14]. This ROM restoration occurred concurrent with pain reduction and functional improvement, suggesting genuine underlying tissue adaptations rather than pain-related movement restriction changes. The mechanism underlying ROM gains likely involves: (1) posteroinferior glenohumeral capsular elongation via sustained stretching component; (2) reduction of posterior shoulder muscular tension (posterior deltoid, infraspinatus) via eccentric loading protocol; (3) improved scapulohumeral rhythm enabling greater apparent ROM through enhanced scapular contribution.

Notably, control group achieved only 2.2° ROM improvement, representing a non-significant change (p=0.089) despite receipt of conventional stretching instruction. This comparison highlights importance of structured protocol specificity and supervised progression, suggesting passive or unsupervised stretching provides insufficient stimulus for meaningful GIRD ROM correction in symptomatic populations. The substantial between-group difference (6.1° mean difference, p<0.001) underscores Theraband intervention superiority over conventional treatment.

Pain Reduction and Functional Improvement

The 4.1-point VAS pain reduction in Theraband group—from moderate-to-severe baseline pain (6.2/10) to mild pain (2.1/10)—represents clinically meaningful improvement. This pain reduction trajectory occurred in parallel with ROM gains and preceded full functional restoration, suggesting pain reduction emerged as early phase benefit enabling progression to higher-intensity functional training. The pain reduction likely reflects multiple contributing factors: (1) reduction of subacromial impingement via posteriorly-directed humeral head repositioning through improved rotator cuff control; (2) decreased posterolateral rotator cuff strain via internal rotation ROM restoration; (3) improved glenohumeral joint proprioception via enhanced eccentric loading; (4) reduced pain-related muscular guarding via successful initial symptom management.

Control group achieved 1.1-point pain reduction (5.8 to 4.7), representing modest improvement insufficient for functional restoration. Statistical significance was achieved (p=0.034) but clinical meaningfulness remains questionable given pain remained moderate and functional limitation persisted. This minimal control group response further highlights the necessity for structured intervention in symptomatic GIRD populations.

The KJOC score improvements (Theraband: +24.1 points vs. Control: +7.2 points) demonstrate functional status restoration beyond simple pain reduction. KJOC scores ≥85 are associated with low injury risk in overhead athletes; Theraband group achieved mean 82.4 (n=5 participants reaching ≥85, optimal status), whereas Control group remained substantially below protective threshold (67.3 mean). This distinction carries clinical significance for return-to-sport decision-making, suggesting Theraband participants demonstrated greater restoration of athletic capacity and injury resilience.

Functional Throwing Assessment and Return-to-Sport

The differential achievement of pain-free throwing in Theraband group (87.5% pain-free spiking) versus Control group (57.1% continued pain during throwing) represents the most clinically meaningful finding. For volleyball athletes, restoration of throwing capacity represents the primary functional outcome and return-to-sport criterion. The 2.3-week earlier mean time to pain-free spiking in Theraband group (5.1 weeks vs. 7.4 weeks) carries practical significance for competitive athletes operating within constrained training calendars.

Pain-free throwing restoration likely reflects: (1) improved glenohumeral joint mechanics via ROM correction; (2) enhanced dynamic stabilization via eccentric rotator cuff retraining; (3) superior scapular control via functional exercise specificity; (4) psychosocial confidence restoration via successful early symptom management enabling progressive intensity escalation. The sport-specific nature of Theraband protocol—incorporating throwing simulation and functional catching exercises—appears particularly valuable for enabling athletes to translate ROM and strength gains into actual throwing function.

Compliance and Adherence Factors

The significant compliance difference between groups (94.2% Theraband vs. 71.3% Control, p=0.001) merits discussion. Supervised structure, systematic progression, individualized feedback, and early symptom improvement in Theraband group likely contributed to superior adherence. The higher control group dropout (28.7% missed sessions) may reflect perceived inefficacy of conventional exercises, lack of supervision accountability, and absence of structured progression system. This compliance difference itself represents an important treatment outcome, as adherence substantially influences rehabilitation success. Supervised Theraband protocols may offer psychological and motivational advantages beyond direct physiological intervention effects.

Mechanism of Theraband Intervention Efficacy

Theraband-based throwing exercise's superior efficacy versus conventional treatment likely reflects multiple interacting mechanisms:

1. Variable Resistance Properties: Theraband resistance increases progressively throughout range of motion (accommodating resistance), providing greatest loading at terminal internal/external rotation where posterior capsule is maximally stretched [15]. This matches resistance profile to anatomical requirements, providing optimal stimulus for capsular elongation and eccentric strengthening.

2. Eccentric Loading Emphasis: The 3-second eccentric phase protocol targets sarcomere length-tension adaptations and neurological recruitment patterns distinct from concentric training[16]. Eccentric loading produces greater force generation and muscle fiber remodeling, translating to superior strength and endurance outcomes.

3. Functional Throwing Simulation: Catching exercises and sport-specific spiking simulations enable neuromuscular pattern retraining in movement patterns resembling actual throwing demands. This task-specificity enhances motor learning transfer to actual sport performance[17].

4. Progressive Overload Systematization: Structured weekly progression (resistance color advancement, repetition increases) ensures continuous stimulus adaptation while preventing plateau effects. Conventional exercise programs often lack formal progression, limiting long-term adaptations.

5. Supervised Implementation: Therapist feedback ensures proper exercise form, appropriate loading intensity, and reinforcement of compliance. Supervised settings also create accountability and motivational environment fostering adherence.

Clinical Implications

1. Treatment Protocol Optimization: Structured Theraband-based protocols should supersede conventional unsupervised exercise for symptomatic collegiate volleyball athletes with GIRD. The superior efficacy, faster recovery timeline, and excellent safety profile support protocol adoption as first-line conservative management.

2. Return-to-Sport Decision-Making: Theraband protocol completion (8 weeks) with achievement of ROM goals (≥29° IR) and pain control (VAS ≤2) provides objective criteria for unrestricted return-to-sport clearance. The high proportion of participants achieving fully unrestricted participation suggests 8-week protocol duration is appropriate for competitive athletes.

3. Injury Prevention Integration: Given GIRD prevalence (89.4%) in volleyball players and association with injury risk, incorporating Theraband prevention protocols into team training programs warrants consideration. Preseason Theraband conditioning may mitigate subsequent injury incidence.

4. Accessibility and Scalability: Theraband's low cost, portability, and minimal equipment requirements enable implementation across diverse settings (clinical, team, home). This accessibility contrasts favorably with interventions requiring sophisticated equipment, supporting broader adoption.

5. Athlete Counseling: Coaches and athletes should understand that pain-free participation resumption represents optimal rather than minimal acceptable outcome. Completing full 8-week protocol predicts superior long-term shoulder health compared to premature competition return.

Study Strengths

1. Randomized Controlled Design: Rigorous RCT methodology with computer-generated randomization and allocation concealment minimizes selection bias.

2. Comprehensive Outcome Assessment: Multiple validated measurement tools (goniometry, VAS, KJOC, functional throwing) provide comprehensive evaluation spanning ROM, pain, function, and sport-specific metrics.

3. Clinical Homogeneity: Population specificity (collegiate male volleyball players) enhances generalizability to target population while reducing confounding from sport-specific demands variability.

4. Complete Follow-up: 100% study completion with no participant attrition strengthens statistical power and eliminates missing data complications.

5. Structured Intervention Protocol: Detailed protocol specification, supervision, and compliance monitoring ensure intervention fidelity and reproducibility.

6. Safety Monitoring: Comprehensive adverse event documentation supports intervention safety profile.

Study Limitations

1. Small Sample Size: Fifteen participants limits statistical power and generalizability, despite achieving primary endpoint significance. Larger multicenter trials would strengthen evidence base.

2. Single-Center Design: Single facility recruitment limits geographic diversity and generalizability to different training environments or populations.

3. Male-Only Population: Exclusion of female athletes limits applicability; female athletes may demonstrate different ROM adaptations or response patterns.

4. Short Follow-Up Period: Eight-week evaluation captures acute intervention response but not long-term sustainability. Follow-up assessment at 6-12 months would determine durability of gains.

5. Control Group Intervention: Conventional exercise control group lacked structured protocol with defined progression; comparison to alternative structured interventions (e.g., scapular stabilization training) would clarify Theraband's relative efficacy.

6. Blinding Limitation: Participant and therapist blinding was impossible given intervention nature, creating potential bias. Assessor blinding was maintained but cannot fully eliminate bias.

7. Confounding Variables: Unmeasured confounders (sleep quality, nutrition, psychological stress, off-protocol activities) could influence outcomes independent of assigned intervention.

Conclusion

This randomized controlled trial establishes that an 8-week Theraband-based throwing exercise protocol is highly effective for managing symptomatic GIRD in collegiate male volleyball players. Compared to conventional active exercise, the Theraband intervention produces superior improvements across all primary outcome measures: internal rotation ROM gains (8.3° vs. 2.2°), pain reduction (4.1 vs. 1.1 VAS points), and functional restoration (24.1 vs. 7.2 KJOC points). Additionally, 87.5% of Theraband participants achieved pain-free throwing by week 8, substantially exceeding control group pain-free achievement (57.1%). The intervention demonstrates excellent safety profile, with minor transient soreness representing sole adverse effect in majority.

These findings support adoption of Theraband-based protocols as first-line conservative management for symptomatic collegiate volleyball athletes with GIRD. The structured protocol, progressive loading, functional specificity, and supervised implementation combine to produce superior efficacy compared to conventional approaches. Early return to pain-free sport participation (5-6 weeks) enables rapid functional restoration critical for competitive athletes. Integration of Theraband prevention protocols into team training programs warrants future investigation as potential injury mitigation strategy.

Clinical practitioners managing overhead athletes should preferentially implement structured Theraband-based throwing exercise protocols rather than conventional stretching-based approaches for symptomatic GIRD. The combination of robust efficacy, rapid functional restoration, excellent safety profile, and practical accessibility supports this treatment approach adoption as evidence-based best practice for this common athlete population.

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