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Original Article

Effect of Thrower's Ten Exercise Program on Shoulder Range of Motion, Functional Capacity, and Quality of Life in Patients with Adhesive Capsulitis: A Randomized Controlled Trial

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Running Title: Thrower's Ten Program for Adhesive Capsulitis

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Abstract:

Objective: Adhesive Capsulitis (AC) is characterized by progressive pain, restricted shoulder mobility, and functional limitations impacting daily activities. Conventional physiotherapy emphasizes mobility restoration, but evidence regarding scapular and rotator cuff–specific strengthening programs such as Thrower's Ten (TT) in AC remains limited. This study evaluated the effect of TT on functional capacity, shoulder range of motion (ROM), and quality of life in individuals with AC.

Material and Methods: Forty-two participants diagnosed with AC (21 per group) were recruited and randomly assigned to two groups. The intervention group received TT exercises combined with conventional physiotherapy, while the control group received conventional physiotherapy alone. Both groups underwent 18 supervised sessions over six weeks. Outcome measures included shoulder ROM (goniometry), functional disability using the Shoulder Pain and Disability Index (SPADI), and quality of life using the 36-Item Short Form Health Survey (SF-36). Assessments were performed at baseline and post-treatment.

Results: Two-way repeated-measures ANOVA showed statistically significant time × group interactions for shoulder abduction ($p=0.031$, $\eta^2p=0.111$), external rotation ($p=0.025$, $\eta^2p=0.120$), SPADI ($p=0.003$, $\eta^2p=0.206$), and SF-36 ($p=0.001$, $\eta^2p=0.226$). No significant interactions were found for shoulder flexion ($p=0.241$, $\eta^2p=0.034$) or internal rotation ($p=0.341$, $\eta^2p=0.023$).

Conclusion: The TT exercise program, combined with conventional physiotherapy, may provide additional benefits in individuals with AC by improving shoulder mobility, functional disability, and quality of life over six weeks. However, these findings should be interpreted cautiously due to the small sample size and lack of long-term follow-up. Further studies are required to confirm the long-term effectiveness and clinical applicability of the TT program in AC rehabilitation.

Keywords: adhesive capsulitis, exercise therapy, range of motion, shoulder joint, quality of life

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Introduction

Adhesive Capsulitis (AC), commonly referred to as frozen shoulder, is a progressive, painful shoulder condition marked by restricted motion and functional impairment of the glenohumeral joint[1]. It affects approximately 2.0–5.0% of the general population, with a higher occurrence among females and individuals 40–60 years of age[2]. Epidemiological studies have reported an increasing incidence among individuals exposed to heavy weight lifting, awkward postures, and repetitive overhead activities[3]. AC has been shown to significantly impact productivity, functional independence, and overall quality of life, making it a persistent socioeconomic burden[4].

Pathologically, AC is characterized by capsular fibrosis, thickening of the joint capsule, and contracture of the coracohumeral ligament[5]. This change results in restricted external rotation, abduction, and flexion, often leading to compensatory movement patterns and secondary muscular imbalances[6,7]. Persistent pain and stiffness may further alter shoulder biomechanics and contribute to further functional decline[8].

Conservative physiotherapy remains the standard intervention, focusing on pain reduction, joint mobility, and functional recovery[1,9,10]. Recent evidence suggests that the strengthening of the rotator cuff and scapular stabilizers plays an important role in restoring coordinated glenohumeral movement and dynamic shoulder stability[11]. Inadequate strengthening may prolong disability, restrict range of motion (ROM), and negatively impact quality of life[12,13].

The Thrower's Ten (TT) program is a structured strengthening protocol consisting of ten isotonic exercises targeting the rotator cuff, scapular stabilizers, deltoid, and biceps muscles[14]. Originally developed for overhead athletes, the program is designed to improve shoulder strength, dynamic stability, and neuromuscular control[14,15]. Considering the biomechanical deficits associated with AC, including rotator cuff weakness, muscular imbalance, and impaired scapulohumeral coordination, the TT program may provide a targeted rehabilitation approach for functional recovery. During the painful stage of AC, low-load TT exercises may help maintain shoulder muscle function and reduce disuse-related weakness. During the freezing stage, the progressive resistive components of the TT program may assist in improving shoulder mobility and functional movement through gradual mechanical loading and progressive engagement of the peri-scapular and glenohumeral musculature. In the thawing stage, the dynamic stabilization

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exercises within the TT program may help to restore coordinated shoulder movement and functional shoulder stability.

Collectively, this stage-specific and mechanistically informed application of the TT program provides a structured rehabilitation approach for individuals with AC. It may offer a clinically relevant framework for improving shoulder function in this complex fibroproliferative condition. However, despite its demonstrated benefits in improving shoulder function in athletic populations[16], evidence regarding its effectiveness in AC remains limited. We hypothesized that the TT program would significantly improve ROM, reduce disability scores, and enhance overall functional performance and quality of life compared to conventional therapy alone. Therefore, the present study investigated the effect of a six-week TT exercise program on shoulder ROM, functional disability, and quality of life in individuals with AC.

Material and Methods

A total of forty-five individuals were recruited clinically, but only forty-two were finalized for the present study based on predefined inclusion and exclusion criteria. Participants were selected using a purposive sampling method from the physiotherapy outpatient department. Individuals aged 40–60 years, experiencing restricted active and passive shoulder ROM for at least three months, and scoring >20% disability on the Shoulder Pain and Disability Index (SPADI) were included in the study. Diagnosis was made on the basis of capsular pattern of restriction, as described by Cyriax, where external rotation was most severely limited, followed by abduction and internal rotation. All participants demonstrated firm capsular end-feel on passive motion testing. Staging was classified according to the Neviaser model[1], with all participants confirmed within Stage II (freezing) or Stage III (frozen). Participants were excluded if they had a history of traumatic shoulder injury, recent corticosteroid injection (within the previous three months), neurological deficits affecting shoulder function, inflammatory or systemic disorders, or if they were undergoing any additional upper-limb rehabilitation training. Additionally, plain radiography was performed in all participants to exclude concurrent bony pathology.

All the eligible individuals were informed about the study procedures, intervention plan, and outcome assessments. Written informed consent was obtained prior to participation. Ethical

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approval was obtained from the Institutional Research and Ethics Committee (ITSCDSR/IIEC/2021-24/XXXXXX/FP/XX). Reporting was done according to the Consolidated Standards of Reporting Trials guidelines.

A priori power analysis using G*Power (version 3.1) confirmed that a minimum of 38 participants were required to achieve 80% statistical power at $\alpha = 0.05$, assuming a moderate effect size of Cohen's $d = 0.65$. The effect size was selected based on conventional statistical recommendations commonly applied in clinical rehabilitation research, as no prior pilot data or directly comparable studies were available during the study planning phase. This value was considered appropriate for detecting clinically meaningful differences between the intervention groups while ensuring adequate statistical power. The total sample size came out to be 42 participants (21 per group) by including 10% dropouts, which was rounded off to 45. This study followed a randomized controlled trial (RCT) design to evaluate the effect of six weeks of the TT exercise on shoulder ROM, functional disability, and quality of life among individuals with AC. Shoulder ROM was assessed in four clinically established directions, including flexion, abduction, external rotation, and internal rotation, consistent with the capsular pattern of restriction described by Cyriax. Moreover, adduction and extension were intentionally excluded as they do not constitute components of the classic AC capsular pattern and demonstrate negligible restriction in this condition. Participants were randomly allocated into two groups using a simple block randomization method with a fixed block size of 4 to ensure equal distribution between groups. The intervention group received the TT program in addition to conventional physiotherapy, and the control group received conventional physiotherapy alone. The flow chart is represented in Figure 1. Sequence randomization was generated by an independent researcher using a computer-generated random number table. To prevent selection bias, allocation concealment was done using sequentially numbered, opaque, sealed envelopes.

Pain intensity was assessed using the Numerical Pain Rating Scale (NPRS), where 0 represents no pain and 10 indicates the worst imaginable pain. Functional disability was assessed using the Shoulder Pain and Disability Index (SPADI), which evaluates pain and functional limitations with a score ranging from 0 to 100, with higher scores indicating greater disability. Quality of life was assessed using the 36-Item Short Form Survey (SF-36), which measures physical functioning, pain, vitality, and emotional well-being.

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Both groups underwent supervised treatment sessions three times a week for six weeks. The control group received conventional physiotherapy consisting of moist heat application for ten minutes followed by pendulum exercises and therapist-assisted pain-free passive and active shoulder ROM exercises[17]. In addition to the conventional protocol, the intervention group participated in the TT exercise program, which consists of ten progressive isotonic strengthening exercises specifically targeting the rotator cuff, deltoid, biceps, and scapular stabilizers[18]. The exercises were performed in a structured sequence beginning with D2 flexion and extension, internal and external rotation exercises, supraspinatus and deltoid strengthening, prone shoulder exercises, biceps and triceps strengthening, rowing exercises, and finally closed-chain exercises such as push-ups and press-ups during weeks 5–6. The detailed description is shown in Table 2 and Table 3. Images of exercise performance in both groups are presented in Figure 2. The exercise dosage and progression were determined based on the established principles of therapeutic exercise and resistance training. Each exercise was performed for three sets of ten repetitions with a rest interval of 30–60 seconds between sets, and resistance was progressively increased using color-coded elastic therabands as tolerated. During the first two weeks, the training comprised 8 repetitions for 3 sets using the red band, allowing neuromuscular adaptation and a pain-free movement pattern. Progression to 10 repetitions for 3 sets with a higher resistance (the green band) during weeks 3–6 was implemented to facilitate strength gains through the principle of progressive overload. The inclusion of closed-chain exercises such as push-ups and press-ups in the later phase (weeks 5–6) was intended to enhance functional strength and joint stability. Resistance values at 100% elongation for the red band are 1.4–1.8 kg and the green band 1.8–2.3 kg approximately, with the green providing greater resistance than the red. Participants were instructed to perform all the exercises within a pain-free range, at a slow and controlled speed, with emphasis on proper scapular positioning and smooth coordinated movement throughout each repetition. All sessions were monitored by a physiotherapist trained in shoulder rehabilitation to ensure standardized exercise performance and adherence to the protocol. Exercise logs were maintained to document exercise participation and progression. To minimize evaluation bias, the final post-treatment assessments were conducted by an examiner blinded to group allocation. Following completion of the six-week intervention period, all participants were reassessed for shoulder ROM using a universal goniometer, functional disability using SPADI, and quality of life using SF-36. Participants were advised not to engage in any additional upper limb strengthening activities

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during the study period. This structured and progressively loaded strengthening approach ensured consistency in treatment delivery and allowed reliable comparison of intervention outcomes.

Statistical analysis

The data were analyzed using IBM SPSS Statistics version 21.0. Descriptive statistics (mean, standard deviation, frequencies, and percentages) were used to summarize demographic characteristics and baseline outcome measures, including shoulder ROM (flexion, abduction, external rotation, internal rotation), SPADI functional disability score, and SF-36 quality-of-life domains. The normality of the data was tested using the Shapiro–Wilk test, and all variables demonstrated a normal distribution; therefore, parametric tests were applied for further analysis.

A two-way repeated-measures analysis of variance (ANOVA) was performed, and the time × group interaction effect was considered the primary outcome to determine differential changes between groups across all variables. To account for multiple comparisons, p-values for the interaction effects were adjusted using the Benjamini–Hochberg false discovery rate (BH-FDR) procedure[19].

Between-group comparisons (TT group vs. control group) were performed using the independent t-test to determine the difference in improvement scores for ROM, SPADI, and SF-36 between the two groups. For all statistical tests, the significance level was set at a p-value < 0.05. Effect sizes were calculated using Cohen's *d* and interpreted as small (0.2), medium (0.5), and large (≥0.8) [20].

Results

The study included 42 participants (24 females and 18 males). No significant baseline differences were observed between the experimental and control groups for age ($p = 0.295$), weight ($p = 0.981$), or height ($p = 0.113$). Exercise adherence exceeded 90% in both groups throughout the six-week intervention period.

Repeated-measures ANOVA with Benjamini–Hochberg False Discovery Rate (BH-FDR) correction demonstrated significant time × group interaction effects for shoulder abduction [$F(1,40) = 4.99$, $p = 0.047$, $\eta^2p = 0.111$], external rotation [$F(1,40) = 5.46$, $p = 0.047$, $\eta^2p = 0.120$], SPADI

[F(1,40) = 10.40, p = 0.018, η^2p = 0.206], and SF-36 [F(1,40) = 11.69, p = 0.006, η^2p = 0.226], favouring the experimental group. Shoulder flexion and internal rotation did not demonstrate significant interaction effects after correction (p > 0.05). Detailed findings are presented in Table 4.

Supplementary between-group analyses at six weeks demonstrated large effect sizes for shoulder abduction (d = 1.54), external rotation (d = 1.06), SPADI (d = 1.60), and SF-36 (d = 3.73). Improvements in external rotation, SPADI, and SF-36 exceeded the established MCID thresholds, whereas shoulder abduction approached clinical relevance. Shoulder flexion and internal rotation did not achieve clinically meaningful improvement. Detailed MCID interpretation is presented in Table 5.

Discussion

The present study demonstrated statistically significant improvements in participants who received the TT exercise program in addition to conventional physiotherapy compared to those who received conventional therapy alone. The findings suggest that incorporating progressive strengthening and scapular-focused exercises may be beneficial in rehabilitation. The most notable improvements were observed in shoulder abduction and external rotation, which are commonly restricted movements in AC[2]. These improvements may be associated with enhanced shoulder muscle performance, improved movement coordination, and better dynamic shoulder stability following progressive resistance training[25]. Improvements in external rotation may be related to the progressive loading of the infraspinatus and teres minor through the external rotation exercises included in the TT program. Similarly, improvements in flexion and abduction may be associated with the inclusion of D2 diagonal movement patterns and scapular-focused exercises that encourage coordinated shoulder movement during elevation. Internal rotation gains may be related to rowing and strengthening exercises that target scapular musculature. However, although statistically significant improvements were observed in shoulder flexion and internal rotation, the mean difference did not exceed the established MCID thresholds, suggesting that the six-week intervention duration may have been insufficient to achieve clinically perceptible improvement in these movements. Our findings are consistent with previous studies reporting that rotator cuff

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strengthening combined with conventional physiotherapy resulted in greater improvements in ROM and SPADI scores compared to conventional treatment alone[12].

The TT program in our study was used for a non-athletic population with AC, despite the fact that it was first created for overhead athletes to improve shoulder strength and dynamic stability [14]. Our findings are consistent with earlier studies showing the benefits of focused resistance and mobility training for shoulder recovery [26]. Participants tolerated the program well, and no adverse effects were reported, suggesting that the intervention was safe and feasible when exercises were performed within a pain-free range and progressed gradually according to tolerance.

The observed functional improvements are also consistent with studies demonstrating that rotator cuff and scapular-focused exercises can improve pain, ROM, and disability in individuals with AC[27]. The TT program emphasizes progressive strengthening and controlled shoulder movements, which may contribute to improved functional performance and shoulder stability.

Compared to passive stretching approaches alone, the structured and progressive nature of the TT program may provide additional functional benefits through progressive strengthening and movement practice[28]. However, these proposed mechanisms should be interpreted cautiously, as the present study did not directly assess neuromuscular activity, proprioception, or biomechanical changes. Previous evidence has emphasized the importance of combining exercise therapy and joint mobilization in the management of AC[13]. In the present study, a combination of TT exercises and conventional therapy not only helped to improve the ROM of the shoulder joint but also improved movement coordination and dynamic stability by using a variety of scapular-focused exercises and proprioceptive neuromuscular facilitation (PNF) patterns. Similar benefits have been reported with PNF-based interventions in individuals with AC[29 30]. The structured and progressive format of the TT program may also support exercise adherence and functional recovery in clinical practice.

Improvements in quality of life observed in the present study are consistent with previous studies reporting beneficial effects of exercise-based and combined rehabilitation approaches in AC[31,32]. Similar improvements have also been reported following rehabilitation combined with nerve block interventions[33]. Overall, the results support the association between functional recovery and improved quality of life in individuals with AC[34]. Although a large effect size was

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observed for SF-36 outcomes, the findings should be interpreted cautiously due to the relatively small sample size and low pooled variability.

Current clinical practice guidelines (CPGs) for AC advocate stage-based, irritability-informed progression from pain-modulating, mobility-focused strategies towards resistive exercise and higher-demand functional activities [35]. The TT protocol used in the present study followed similar rehabilitation principles through progressive loading and gradual introduction of higher-demand functional exercises according to patient tolerance. This progressive approach may have contributed to the observed improvements in shoulder ROM, functional disability, and quality of life.

It is necessary to recognize certain restrictions in the present study. Despite the randomized controlled trial (RCT) design, the relatively small sample size and purposive recruitment from a single outpatient department may limit the external validity and generalizability of the study findings. Therefore, caution is warranted when applying these results to broader clinical populations. The absence of long-term follow-up beyond the six-week intervention period limits the ability to determine whether observed improvements were sustained or partially reflective of the self-limiting nature of AC. Although the supervising physiotherapist received standardized training, the possibility of therapist performance bias accumulating over the intervention period cannot be entirely excluded. Furthermore, exercise adherence was not formally monitored through an objective tool, which may have introduced variability in intervention fidelity across participants.

Conclusion

This study concludes that the TT exercise program, when combined with conventional rehabilitation, may provide additional benefits in the management of AC. The program appeared to improve shoulder mobility, pain, functional ROM, disability, and quality of life over the six-week intervention period. Conventional exercises may further support recovery through general musculoskeletal conditioning. However, these findings should be interpreted cautiously due to the relatively small sample size, self-limiting nature of AC, absence of long-term follow-up, and limited generalizability. Future research should be conducted with extended follow-up durations

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to confirm the long-term effectiveness and clinical applicability of the TT program across diverse patient populations.

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Conflict of Interest

There is no conflict of interest.

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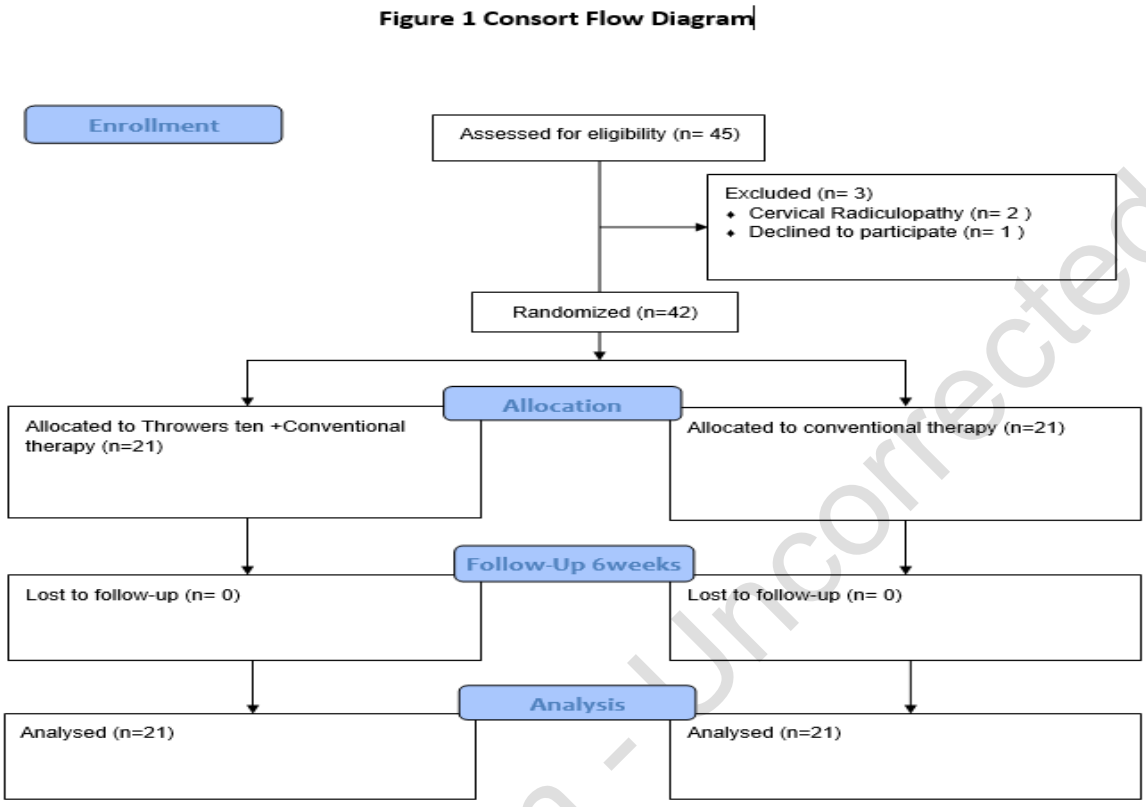

Figure 1 Consort flow diagram

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Table 1 TT Exercise Regimen

Exercise	**Dosage**	**Week**
D2 Flexion and Extension	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Internal & External Rotation at 0° Abduction	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Internal & External Rotation at 90° Abduction	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Supraspinatus & Deltoid Strengthening	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Prone Shoulder Abduction (D2 Flexion)	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Prone Shoulder Extension	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Biceps & Triceps Strengthening	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Rowing	8 reps × 3 sets Red band 10 reps × 3 sets Green band	1st-2nd week 3rd-6th week
Push-ups	10 reps × 3 sets	5th-6th week
Press-ups	10 reps × 3 sets	5th-6th week

Table 2 Conventional Therapy Regimen

Position	**Exercises**	**Dosage**
Standing	Wand-assisted movements: Flexion, abduction, extension, internal rotation	3 sets of 10 repetitions per exercise
Standing	Pendulum (Codman's) exercises: Flexion, abduction, circumduction	3 sets of 10 repetitions per exercise
Lying	Capsular stretching: Anterior, posterior, and inferior shoulder capsules	3 sets of 10 repetitions per exercise

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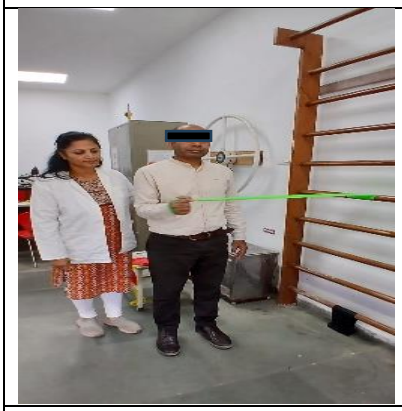
Figure 2 Pictures of patient representing TT and conventional exercises

		
Initial range of motion	D2 flexion and extension	Internal rotation at 0° abduction
		
External rotation at 0° abduction	Internal rotation at 90° abduction	External rotation at 90° abduction
		
Deltoid strengthening	Prone shoulder abduction	Bicep strengthening



Rowing exercise



Push up



Press up



Anterior capsular stretching



Inferior capsular stretching



Wand exercise



Pendular exercise

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Figure 2 Pictures of patient representing TT and conventional exercises

Table 3 Baseline Characteristics of the Population

	Experimental Group (Mean ±S.D.)	**Control Group (Mean ±S.D.)**	**t-value**	**p-value**
Age	51.2±5.6	50.4±4.9	1.06	0.295
Height	167.3 ±6.1	165.8±5.7	-0.02	0.981
Weight	72.6±8.3	74.1±7.9	-2.59	0.113

*p-value <0.05 represent significant result. All the values are presented as mean and standard deviation (S.D.).

Table 4 Time × Group Interaction: Repeated Measures ANOVA with BH-FDR Correction

Outcome Variable	**F (1, 40)**	**p-value**	**BH-FDR adjusted p**	**η^2p**	**Significance**
Shoulder Flexion	1.41	0.241	0.289	0.034	NS
Shoulder Abduction	4.99	0.031	0.047	0.111	Significant
External Rotation	5.46	0.025	0.047	0.120	Significant
Internal Rotation	0.93	0.341	0.341	0.023	NS
SPADI	10.40	0.003	0.018	0.206	Significant
SF-36	11.69	0.001	0.006	0.226	Significant

F = F-statistic with df (1, 40) | η^2p = Partial Eta Squared | BH-FDR = Benjamini-Hochberg False Discovery Rate correction applied across 6 comparisons, Effect size: small = 0.01–0.06, medium = 0.06–0.14, large ≥ 0.14 (Cohen)[20]. * p < .05, NS = Not Significant

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Table 5 Between-Group Differences with Clinical Significance at 6 Weeks

Variables	Experimental Group Mean ±S.D.	Control group Mean ±S.D.	Mean Difference	p-value	MCID Threshold	MCID Achieved
Flexion	147.1 ±8.2	139.0 ±8.3	8.1	0.040*	~ 10°	✗ Not exceeded
Abduction	147.3± 6.2	137.5 ±6.5	9.8	0.001*	~10°	△ Borderline
External Rotation	64.3± 7.5	57.4 ± 5.4	6.9	0.001*	~5°	✔ Exceeded
Internal Rotation	63.7± 5.4	59.8 ±5.1	4.0	0.019*	~5°	✗ Not exceeded
SPADI	50.4± 8.8	62.9 ± 6.5	12.4	<0.001*	~10°	✔ Exceeded
SF36	95.1 ± 2.9	83.3 ± 3.4	11.9	<0.001*	~5°	✔ Exceeded

Note: *p-value<0.05, represent significant results ** Independent t-test used to calculate p-values. All the values are presented as mean ± standard deviation (S.D). MCID= Minimal clinically important difference.

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