

EFFECTS OF END-RANGE MOBILIZATION VERSUS MULTIPLE-ANGLE ISOMETRIC TRAINING ON PAIN, RANGE OF MOTION, AND FUNCTIONAL OUTCOMES IN DIABETIC FROZEN SHOULDER: A RANDOMIZED CONTROLLED TRIAL

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DOI: <https://doi.org/10.5281/zenodo.22872214>

Keywords

Adhesive capsulitis; Diabetic frozen shoulder; End-range mobilization; Multiple-angle isometric training; Shoulder rehabilitation

Article History

Received: 14 June 2026

Accepted: 05 September 2026

Published: 21 September 2026

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Abstract

Background: Adhesive capsulitis, commonly known as frozen shoulder, is characterized by progressive shoulder pain, capsular stiffness, restricted active and passive range of motion (ROM), and functional disability. Diabetes mellitus substantially increases the risk of adhesive capsulitis and may contribute to a prolonged and less predictable recovery. Although end-range mobilization and multiple-angle isometric training are commonly used physiotherapy interventions, direct comparative evidence in patients with diabetic frozen shoulder remains limited.

Objective: To compare the effects of end-range mobilization and multiple-angle isometric training on pain, shoulder ROM, and functional disability in patients with diabetic frozen shoulder.

Methods: A randomized controlled trial was conducted at Sheikh Zayed Hospital, Lahore. Forty-four participants with diabetic frozen shoulder were randomly allocated into two groups (n=22 each). Group A received end-range mobilization plus conventional physical therapy, whereas Group B received multiple-angle isometric training plus conventional physical therapy. Treatment was provided for four weeks. Pain was measured using the Numeric Pain Rating Scale (NPRS), functional disability using the Shoulder Pain and Disability Index (SPADI), and shoulder flexion, abduction, and external rotation using a goniometer. Paired-samples and independent-samples t-tests were used for statistical analysis.

Results: Both groups demonstrated substantial numerical improvements after treatment. Post-intervention comparisons significantly favored Group A for SPADI, NPRS, shoulder flexion, abduction, and external rotation (all $p < 0.001$). Post-treatment NPRS scores were 2.75 ± 0.805 in Group A and 5.43 ± 0.523 in Group B, while SPADI scores were 37.71 ± 0.860 and 40.82 ± 0.976 , respectively.

Conclusion: End-range mobilization combined with conventional physical therapy produced greater short-term post-treatment improvements than multiple-angle isometric training across the measured outcomes. However, the within-group statistical pattern reported in the source data warrants cautious interpretation.

Introduction

Adhesive capsulitis, also known as frozen shoulder, is a musculoskeletal disorder which occurs as a progressive shoulder pain and loss of passive and active range of motion [1]. The most common movement to be compromised is external rotation, followed by abduction and flexion [2]. These restrictions may significantly affect daily functions like dressing, grooming, overhead reaching, reaching behind the back and other functions that depend on functional shoulder mobility[3].

Diabetes mellitus is an important risk factor for adhesive capsulitis. Frozen shoulder occurs about two to four times more often in people with diabetes than in those who do not have diabetes [4]. Non-enzymatic glycation of collagen and the production of advanced glycation end-products (AGEs) may be promoted by chronic hyperglycaemia [5]. These products may build up and cross-link to make the capsule stiffer and cause chronic limitation of glenohumeral movement [6]. Therefore, diabetic adhesive capsulitis can potentially be more chronic, and less responsive to rehabilitation, than idiopathic frozen shoulder [7].

Conservative physiotherapy is an important part of the treatment of frozen shoulder. Patients are educated, therapeutic modalities applied, stretching, strengthening exercises, home exercise programmes and joint mobilisation techniques are commonly used [8]. There is no universally agreed upon conservative treatment that is best for all patients, however. The choice of treatment might be influenced by pain severity, capsular restriction, disease stage, systemic condition, and patient response to rehabilitation [9].

End-range mobilization is a passive manual therapy technique mainly aimed at the restricted capsular tissue. Grade III-IV mobilizations are done at the end of the available range to stretch shortened capsular structures and enhance joint mobility [10]. Multiple-angle isometric exercise, on the other hand, is an active rehab method in which muscles are exercised isometrically (without joint motion) at several angles of the range of motion [11]. This enables strengthening of the muscle while avoiding the repetitive motion of

the shoulder across a painful range of motion [12].

There is evidence for both approaches to treat adhesive capsulitis, but much of the research has been performed in idiopathic patient's non diabetic patients. Clinically relevant since diabetes-related connective-tissue changes might modify the effects of mechanical loading and rehabilitation [13]. A review of the literature revealed no direct comparisons between end-range mobilization and multiple-angle isometric training in patients with diabetic frozen shoulder. Therefore, the purpose of this study was to compare the effectiveness of end-range mobilization and multiple-angle isometric training on pain, shoulder ROM, and functional disability in patients with diabetic frozen shoulder.

Materials and Methods**Study Design and Setting**

This study was a randomized controlled trial conducted at Sheikh Zayed hospital Lahore. The entire study period lasted for six months after approval of the study synopsis.

Participants and Sample Size

A sample size was determined with G*Power software, based on the SPADI values from a previous comparative study. A 95% level of statistical power at $\alpha = 0.05$ was used. An optimum sample size of 36 participants was determined. With an expected 20% attrition rate, the sample was expanded to 44 participants, with 22 participants per intervention group [14]. Non-probability, convenience sampling was used for participants. Eligible participants were those with a diagnosis of diabetes mellitus, shoulder pain ≥ 3 on the NPRS [15], and $\geq 25\%$ loss of motion in 2 or more shoulder movements from the unaffected side [16]. Exclusion criteria included a history of recent shoulder surgery [17], fracture [17], rotator cuff tear [18], neurological deficits [19], systemic inflammatory disease [20], cervical radiculopathy [21], malignancy, or recent corticosteroid injection.

Randomization and Blinding

After the baseline assessment, the participants were randomly allocated to Group A or B by using computer-generated method of randomisation. A blinded assessor re-evaluated post interventions. Informed consent, in writing, was obtained prior to participation.

Outcome Measures

The Numeric Pain Rating Scale (NPRS) was used to determine the intensity of pain, where 0 meant no pain and 10 meant the worst pain imaginable [22]. Functional disability was measured by the Shoulder Pain and Disability Index (SPADI) [23]. Measurement of shoulder flexion, abduction and external rotation was performed in degrees with a universal goniometer [24].

Intervention Protocol

Group A - End-Range Mobilization: Participants received grade III-IV sustained and oscillatory glenohumeral mobilisations at the end of their available range of motion. The mobilizations were applied posterior, inferior and anterior with rotational movements to increase capsular extensibility [25].

Group B - Multiple-Angle Isometric Training: Participants completed isometric contractions at 3-5 joint angles throughout the pain-free

range of the shoulder flexors, abductors and rotators. The number of repetitions of each contraction was 10 at each angle and the duration was 8-10 seconds [26].

Both interventions were conducted about 30 minutes per session, three sessions per week for four weeks. The groups were also treated with conventional physical therapy, such as Codman's pendulum exercises.

Statistical Analysis

The data were analyzed using SPSS version 25. Data were presented as means, SDs, frequencies and percentages. The Shapiro-Wilk test was used to evaluate normality. The within-group comparisons were conducted with paired-samples t-tests and the between-group comparisons were conducted with independent-samples t-tests if the data was normally distributed. The significance of the values was considered as $p \leq 0.05$.

Results

All 44 participants were allocated equally between the two treatment groups. Group A consisted of 13 males (59.1%) and nine females (40.9%), while Group B included 16 males (72.7%) and six females (27.3%). Mean age was 54.55 ± 7.46 years in Group A and 55.64 ± 7.10 years in Group B.

Table 1. Demographic Characteristics of Participants

Characteristics	Group A: End-Range Mobilization (n=22)	Group B: Multiple-Angle Isometric Training (n=22)
Age (years), Mean $\pm$ SD	54.55 ± 7.46	55.64 ± 7.10
Male, n (%)	13 (59.1%)	16 (72.7%)
Female, n (%)	9 (40.9%)	6 (27.3%)
Total, n (%)	22 (100%)	22 (100%)

Both groups demonstrated numerical improvements from baseline to the end of the fourth week. SPADI decreased from 66.63 ± 3.195 to 37.71 ± 0.860 in Group A and from 69.12 ± 3.179 to 40.82 ± 0.976 in Group B.

NPRS decreased from 7.49 ± 0.913 to 2.75 ± 0.805 in Group A and from 7.58 ± 0.937 to 5.43 ± 0.523 in Group B. Shoulder ROM also increased in both groups.

Table 2. Comparison of Pre- and Post-Intervention Outcomes

Outcome Measure	Group A Baseline Mean $\pm$ SD	Group A Week 4 Mean $\pm$ SD	Group B Baseline Mean $\pm$ SD	Group B Week 4 Mean $\pm$ SD
SPADI	66.63 $\pm$ 3.195	37.71 $\pm$ 0.860	69.12 $\pm$ 3.179	40.82 $\pm$ 0.976
NPRS	7.49 $\pm$ 0.913	2.75 $\pm$ 0.805	7.58 $\pm$ 0.937	5.43 $\pm$ 0.523
Flexion ROM (°)	75.27 $\pm$ 1.241	138.32 $\pm$ 0.894	75.95 $\pm$ 1.090	134.55 $\pm$ 1.057
Abduction ROM (°)	76.95 $\pm$ 1.174	140.95 $\pm$ 0.722	77.00 $\pm$ 1.155	137.95 $\pm$ 0.844
External Rotation ROM (°)	25.55 $\pm$ 1.535	44.14 $\pm$ 0.834	25.00 $\pm$ 1.234	40.77 $\pm$ 0.752

The post-intervention between-group comparison favored Group A for all measured outcomes. Mean differences were -3.118 for SPADI, -2.681 for NPRS, 3.773° for flexion,

3.000° for abduction, and 3.364° for external rotation. All between-group post-intervention comparisons were reported as statistically significant.

Table 3. Between-Group Comparison of Post-Intervention Outcomes

Outcome Measure	Mean Diff	t-value	p-value
SPADI	-3.118	-11.243	<0.001
NPRS	-2.681	-13.102	<0.001
Flexion ROM	3.773	12.785	<0.001
Abduction ROM	3.000	12.668	<0.001
External Rotation ROM	3.364	14.057	<0.001

Note: Negative differences for SPADI and NPRS indicate lower post-treatment pain/disability scores in Group A, whereas positive differences for ROM indicate higher post-treatment ROM in Group A.

Discussion

This randomized control study compared end-range mobilization to multiple-angle isometric training in patients with diabetic frozen shoulder. Numerous improvements were noted in both groups after 4 weeks of intervention, and post-treatment comparisons between groups favored the end-range mobilization group for pain, disability, flexion, abduction and external rotation. Group A showed a significant decrease in NPRS from 7.49 $\pm$ 0.913 at baseline to 2.75 $\pm$ 0.805 after the intervention, while Group B had a moderate decrease from 7.58 $\pm$ 0.937 to 5.43 $\pm$ 0.523. This increase in reduction after end-range mobilization could be linked to mechanical and/or neurophysiological effects. Mobilizing to the end range of possible movement results in controlled mechanical loading of the limited capsule and can have an effect on nociceptive

processing due to the stimulation of joint mechanoreceptors. ROM findings were similar. Group A showed higher post-treatment scores for shoulder flexion, abduction and external rotation. End-range mobilization is a technique that is particularly designed to lengthen shortened capsular structures and to increase glenohumeral mobility. It is possible that this mechanism is especially important in DTS, as collagen cross-linking and higher stiffness of connective tissue have been linked to long-term hyperglycaemia [27].

Significant improvement was observed in functional disability as well. SPADI decreased from 66.63 $\pm$ 3.195 to 37.71 $\pm$ 0.860 in Group A and from 69.12 $\pm$ 3.179 to 40.82 $\pm$ 0.976 in Group B. Previous studies reviewed in the thesis similarly reported functional improvements following Maitland and end-range mobilization approaches. However, multiple-angle isometric training did show significant improvement and is a valid treatment method. Isometric contraction enables the loading of the muscles without the need to constantly take the shoulder through painful arcs. They can thus be very beneficial in

cases where the dynamic strengthening is limited due to pain or when active muscular strengthening is a key rehabilitation goal [28].

Both intervention groups received standard physical therapy, and this could also have been a contributing factor in the changes observed. Codman's pendulum exercise, and supervised therapeutic contact are common practices and it is not possible to rule out improvements as being due to either of the two experimental procedures. Furthermore, factors such as glycaemic control and general activity level were not directly controlled and could have influenced treatment response [29].

Limitations

There are some limitations to this study. First, the study only included 44 participants from one clinical site and by convenience sampling, the findings were not generalizable. Second, there was no medium or long-term follow up, only a four week intervention. As a result, it is unknown whether or not the differences seen would last. Furthermore, blood glucose control (HbA1c) and the duration of diabetes were not measured and/or adjusted for as potential covariates. Psychosocial and disease related factors, such as stress and sleep disturbance were also not assessed.

Clinical Implications

The study recommends that passive joint mobilization combined with active isometric training may be included in conservative rehabilitation for diabetic frozen shoulder. Scores were more favorable at end range mobilization than other interventions across the four week period, especially pain, functional disability, and shoulder ROM. Treatment should however be individualized based on pain irritability, capsular restriction, ROM available, patient tolerance, and ability to participate in active exercise. A combined treatment protocol could also be explored in future studies as end-range mobilization and multiple-angle isometric training target the different sides of the shoulder dysfunction.

Conclusion

End range mobilization and multiple-angle isometric exercises with traditional physical

therapy were both significantly correlated with numerical improvements in pain, shoulder ROM, and functional disability in patients with diabetic frozen shoulder at four weeks. Post-intervention comparisons showed an advantage for end-range mobilization on NPRS, SPADI, shoulder flexion, abduction, and external rotation, all of which were <0.001 .

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