JHWCR
Journal of Health, Wellness, and Community Research
Volume III, Issue I
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, **ISSN**: 3007-0570
https://doi.org/10.61919/cte3sx07

Article

Effectiveness of Ultrasound Therapy Combined with Shoulder Glides and Range of Motion Exercises for Adhesive Capsulitis Among Diabetic Population

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Cite this Article

Received	2024-12-17
Revised	2025-01-11
Accepted	2025-01-16
Published	2025-01-30

No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

Authors' Contributions
Concept: RK, FK; Design: NK, AF; Data Collection: AQ, RK; Analysis: FK, NK; Drafting: AF, AQ

ABSTRACT

Background: Adhesive capsulitis is a common and disabling shoulder condition that occurs with increased frequency and severity in individuals with diabetes mellitus, where capsular fibrosis and stiffness cause pain, sleep disturbance, and functional limitation. Combining physical agent modalities with manual therapy or exercise is widely practised, but comparative evidence in diabetic frozen shoulder remains limited. **Objective**: To compare the effectiveness of therapeutic ultrasound combined with Kaltenborn shoulder glides versus therapeutic ultrasound combined with range of motion (ROM) exercises in improving pain, disability, and shoulder ROM in diabetic patients with adhesive capsulitis. **Methods**: In this randomized controlled trial, 38 diabetic adults with idiopathic adhesive capsulitis were allocated to either ultrasound plus Kaltenborn glides (n=19) or ultrasound plus ROM exercises (n=19). Interventions were delivered in government hospital physiotherapy departments. Shoulder pain and disability were assessed using the Shoulder Pain and Disability Index (SPADI), and active abduction and external rotation were measured with a goniometer at baseline and post-treatment. Data were analysed using paired and independent-samples t-tests with $p<0.05$ considered significant. **Results**: Both groups showed significant within-group improvements in SPADI pain and disability items and in shoulder abduction and external rotation. However, reductions in pain and disability were consistently greater in the Kaltenborn glides group, while ROM gains were large and comparable between groups. No treatment-related adverse events were observed. **Conclusion**: In diabetic adhesive capsulitis, ultrasound-based rehabilitation is effective when combined with either Kaltenborn mobilization or ROM exercises, but adding joint glides to ultrasound yields superior improvements in pain and disability without compromising ROM recovery.
Keywords: adhesive capsulitis; frozen shoulder; diabetes mellitus; Kaltenborn mobilization; ultrasound therapy; range of motion exercises.

INTRODUCTION

Adhesive capsulitis is a chronic, self-limiting shoulder disorder characterized by progressive pain, capsular fibrosis, and marked restriction of active and passive glenohumeral motion, particularly forward elevation and external rotation (1–3). The clinical course typically evolves through painful "freezing," stiff "frozen," and recovery "thawing" phases over months to years, often resulting in substantial functional limitation, sleep disturbance, and impaired quality of life (1,4,5). Epidemiological estimates suggest a prevalence of 2–5% in the general population, with higher rates among women and individuals between 40 and 65 years of age (2,4,5). Diagnostic frameworks and clinical practice guidelines emphasize a combination of characteristic history, capsular pattern of movement loss, and specific clinical signs such as coracoid tenderness to differentiate adhesive capsulitis from other causes of shoulder pain and stiffness (3,4,6,7). Conservative treatment is generally recommended as first-line management, with surgical options reserved for refractory cases (4,5,8).

Diabetes mellitus is a well-recognized risk factor for adhesive capsulitis, with reported prevalence ranging from approximately 10% to over 30% among people with diabetes, and a tendency towards more severe and persistent symptoms compared with non-diabetic populations (2,5). Chronic hyperglycaemia and non-enzymatic glycation of collagen are thought to promote capsular thickening, abnormal cross-linking, and fibroblastic proliferation, leading to contracture of the glenohumeral capsule and reduced joint volume

(2,5). These mechanisms, compounded by reduced shoulder use due to pain and comorbidities, may explain the higher burden and slower recovery observed in diabetic patients. In low- and middle-income countries, including Pakistan, diabetes-related musculoskeletal complications such as frozen shoulder are particularly important because they further increase disability in already vulnerable populations and add to healthcare utilisation and indirect costs (2,4,5,8).

A wide range of non-operative interventions has been evaluated for adhesive capsulitis, including supervised and home-based exercise programmes, manual therapy, electrotherapeutic modalities, corticosteroid or hyaluronate injections, and hydrodilatation, with or without subsequent physiotherapy (4,5,8,16,17,23,24). Clinical guidelines highlight the central role of exercise therapy and joint mobilisation to regain capsular extensibility and restore functional range, while acknowledging that no single protocol has been proven universally superior (4,5). Manual therapy approaches such as Kaltenborn and Mulligan techniques aim to restore normal arthrokinematics using graded traction and gliding mobilisations, often combined with stretching and strengthening exercises to optimise outcomes (5,17). Comparative studies of different manual therapy strategies show clinically meaningful improvements in pain and range of motion, although results are heterogeneous and the optimal combination with physical agents remains uncertain (17,29–31).

Therapeutic ultrasound is one of the most frequently used physical agent modalities in shoulder rehabilitation and is commonly applied in conditions such as rotator cuff tendinopathy, subacromial bursitis, and adhesive capsulitis (9–11,16,17,23,24). Continuous ultrasound at appropriate intensity and frequency increases tissue temperature, blood flow, capillary permeability, and collagen extensibility, while modulating inflammation and pain perception (9–15). Experimental work has demonstrated predictable temperature rises within muscle and periarticular tissues during 1 MHz and 3 MHz ultrasound, supporting its role as a deep heating modality when applied with evidence-based parameters (13–15). However, clinical trials in adhesive capsulitis have produced mixed results, with some studies reporting ultrasound to be no more effective than sham or placebo when used in isolation, and others suggesting benefit when combined with stretching or mobilization (16,17,23,24). A recent randomized trial, for example, reported that therapeutic ultrasound added to conventional physiotherapy yielded significant improvements in pain and function compared with placebo, whereas other work has found comparable or superior results with alternative modalities such as interferential therapy (16,23,24,29,30).

Within this complex therapeutic landscape, combining deep heating modalities with targeted manual therapy may be particularly relevant in diabetic adhesive capsulitis, where capsular stiffness and soft-tissue extensibility are key limitations. Kaltenborn joint mobilisation grades I–III provide a structured framework for applying distraction and gliding forces parallel or perpendicular to the joint surface to reduce pain, stretch periarticular tissues, and restore accessory motion, while respecting the convex–concave rule of arthrokinematics (5,17). Ultrasound applied immediately before or during mobilisation may enhance capsular elasticity and permit more effective gliding, potentially translating into greater gains in range of motion and pain relief than exercise programmes alone (9–15,17,23,24,29–31). At the same time, range of motion (ROM) exercises—whether passive, active-assisted, or active—remain the mainstay of rehabilitation, and are widely recommended in clinical guidelines for adhesive capsulitis (4,5,17).

Despite the widespread use of physical agents and manual therapy in adhesive capsulitis, robust controlled data directly comparing ultrasound combined with Kaltenborn glides versus ultrasound combined with ROM exercises in diabetic patients are scarce, particularly in South Asian settings. Many previous trials have either included mixed diabetic and non-diabetic populations, focused on single modalities rather than specific combinations, or have been conducted in high-income countries with different health system contexts (4,5,16,17,23,24,29–31). There is therefore a clinically relevant knowledge gap regarding whether adding joint glides confers incremental benefit over structured ROM exercises when both are delivered alongside therapeutic ultrasound in diabetic frozen shoulder. Addressing this gap is important for optimising resource allocation and treatment protocols in government hospital physiotherapy services.

MATERIAL AND METHODS

On this basis, the present randomized controlled study was designed to compare the effectiveness of ultrasound therapy combined with Kaltenborn shoulder glides versus ultrasound therapy combined with ROM exercises in diabetic patients with adhesive capsulitis. The primary outcomes were shoulder pain and disability measured using the Shoulder Pain and Disability Index (SPADI), a validated instrument for assessing shoulder-related pain and functional limitation (22). Secondary outcomes were active shoulder abduction and external rotation measured with a universal goniometer. The research question was: among diabetic adults with idiopathic adhesive capsulitis, does a programme of ultrasound plus Kaltenborn shoulder glides lead to greater improvement in shoulder pain, disability, and ROM than ultrasound plus ROM exercises alone? The corresponding hypothesis was that the Kaltenborn glides plus ultrasound protocol would produce significantly larger improvements in SPADI scores and shoulder ROM than the ROM exercises plus ultrasound protocol.

The study was designed as a randomized controlled experimental trial comparing two physiotherapy interventions in patients with diabetic adhesive capsulitis managed in the physiotherapy departments of government hospitals in Faisalabad, Pakistan. Adult participants aged 45–65 years with a clinical diagnosis of idiopathic adhesive capsulitis in the subacute phase were eligible if they reported shoulder pain, demonstrated capsular pattern restriction, and had difficulty performing activities of daily living. Range of motion criteria included reduced flexion to 0–60°, external rotation reduced by approximately 30–40°, internal rotation reduced by

20–30°, extension reduced by 10–20°, and abduction limited to 60–70°, consistent with standard clinical definitions of frozen shoulder (1–5). Only patients with diabetes mellitus and primary (idiopathic) adhesive capsulitis were enrolled, reflecting the specific population of interest. Exclusion criteria comprised age below 35 or above 65 years, absence of diabetes, pregnancy, presence of a pacemaker, secondary adhesive capsulitis following trauma or surgery (including cardiac surgery), other intrinsic shoulder pathologies such as impingement syndrome or rotator cuff tear, prior stabilising shoulder surgery, radiating pain beyond the elbow, cervical spine pain, and systemic conditions known to affect musculoskeletal function such as stroke, osteoporosis, or rheumatoid arthritis (4,5,8).

Participants were recruited consecutively from outpatient physiotherapy clinics after referral by orthopedic or medical services and were screened against the predefined eligibility criteria by a physiotherapist. Those meeting criteria were provided with verbal and written information about the study and invited to participate. Written informed consent was obtained from all participants before any study-specific procedures, including baseline assessment. The study protocol adhered to ethical principles for human research and was approved by the relevant institutional ethics committee. Recruitment and treatment were conducted over a defined study period, during which all eligible and consenting patients were invited to participate until the target sample size was reached.

A total sample of 38 subjects was enrolled and randomly allocated in a 1:1 ratio to one of two treatment groups using a simple random sampling (lottery) method. Nineteen participants were assigned to the Kaltenborn group, receiving ultrasound therapy combined with shoulder glides, and 19 to the ROM group, receiving ultrasound therapy combined with ROM exercises. The randomisation procedure was implemented to balance known and unknown confounders between groups; however, blinding of therapists and patients was not feasible due to the nature of the interventions. To minimise allocation bias, group assignment was performed after completion of baseline measurements. All participants completed a standardised consent form, and the same core assessment protocol was applied before and after the intervention period.

The primary outcomes were shoulder pain and disability measured by the Shoulder Pain and Disability Index (SPADI), which comprises pain and disability subscales assessing pain intensity during specific shoulder movements and functional limitations in daily activities (22). A structured SPADI questionnaire was administered to all participants at baseline and immediately after completion of the intervention protocol. Pain intensity items included lying on the involved side and touching the back of the neck, while disability items included washing the back and placing objects on a high shelf. Participants rated each item on a numerical scale, and scores were used to derive item-level change scores for analysis. The SPADI has demonstrated good reliability, responsiveness, and validity in shoulder disorders, supporting its use in clinical trials (22).

Secondary outcomes were active shoulder abduction and external rotation of the affected side measured with a standard universal goniometer by a trained physiotherapist using established positioning and alignment techniques (1–5). Baseline ROM was recorded prior to the first treatment session, and follow-up measurements were obtained after the final treatment session using the same procedure to minimise measurement variability. For each motion, the difference between post-treatment and baseline measurements was calculated to quantify change in degrees. Range of motion values were recorded to the nearest degree, and consistent landmarks were used for repeated measurements to enhance reproducibility.

The experimental intervention in the Kaltenborn group consisted of therapeutic ultrasound applied to the shoulder region followed by Kaltenborn joint mobilization techniques targeting the glenohumeral joint. Ultrasound was administered using a clinically standard device in continuous mode as a deep heating modality, with parameters selected in accordance with recommendations for musculoskeletal soft tissue heating in adhesive capsulitis and related conditions (9–15,16,17,23,24). Application was directed over the anterolateral shoulder and capsule region, with appropriate coupling medium and treatment duration sufficient to achieve therapeutic heating. Immediately after ultrasound, Kaltenborn mobilizations (grades I–III) were performed by the physiotherapist, including traction and gliding techniques aligned with the treatment plane and convex–concave rule to reduce pain (grade I), tighten periarticular tissues (grade II), and stretch the capsule to improve ROM (grade III) (5,17,29–31). Mobilizations were applied within patient tolerance, with careful monitoring of pain response and joint end feel.

The comparison intervention in the ROM group consisted of the same ultrasound protocol followed by a structured programme of ROM exercises without joint glides. Exercises included passive, active-assisted, and active movements such as pendulum (Codman) exercises, pulley-assisted elevation, wall-climbing or ladder exercises, and progressive stretching and strengthening within the available range. The programme emphasised restoring elevation and rotation while encouraging functional use of the arm. Exercise dosage (repetitions and sets) and progression were standardised using a written protocol and adjusted according to individual tolerance and symptom response, consistent with guideline-based practice for adhesive capsulitis (4,5,17,23,24).

To reduce performance bias, both groups received their respective interventions from physiotherapists trained in the study protocols, and the same therapeutic ultrasound equipment and general treatment environment were used in all sessions. Outcome assessments were conducted using standardised instructions and measurement techniques. The SPADI questionnaire was self-reported but supervised to ensure clarity and completeness, and goniometric measurements were taken using the same instrument and landmarks across assessments. Data were entered into a password-protected database and cross-checked to enhance data integrity.

The primary analytic approach focused on within-group changes from baseline to post-treatment in SPADI item scores and ROM measures, and on between-group differences in these change scores. Data were analysed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were summarized using means and standard deviations, whereas categorical variables were expressed as frequencies and percentages. Paired t-tests were applied within each group to test whether pre–post changes in SPADI items and ROM were statistically significant. Independent-samples t-tests were used to compare mean change scores between the Kaltenborn and ROM groups for each outcome. Two-sided p-values <0.05 were considered statistically significant. For each comparison, 95% confidence intervals (CIs) for mean change and for between-group differences were calculated, and standardized effect sizes (Cohen's d) were derived as the mean change divided by the standard deviation of the change score to facilitate interpretation of clinical magnitude. The analysis assumed data were approximately normally distributed; given the modest sample size and the continuous nature of the outcomes, parametric tests were considered appropriate. No imputation was performed for missing data, as all randomised participants who completed baseline assessment were followed to post-treatment. The overall design, outcome selection, and analytic framework were aligned with contemporary standards for rehabilitation trials and outcome measurement in musculoskeletal disorders (18–24).

RESULTS

A total of 38 diabetic patients with idiopathic adhesive capsulitis were enrolled and randomized, with 19 allocated to the Kaltenborn glides plus ultrasound group and 19 to the ROM exercises plus ultrasound group. All participants completed the intervention and post-treatment assessment, and there were no reported adverse events related to the treatments. The sample was predominantly female (55.2%), with males accounting for 44.8%. Most participants were aged 55–65 years (65.8%), while 34.2% were between 45 and 54 years, reflecting the typical age distribution of adhesive capsulitis (1–5). Baseline clinical features were consistent with subacute frozen shoulder in both groups, with marked restriction of external rotation and abduction and substantial pain and disability in daily activities.

Post-treatment SPADI item responses demonstrated clinically relevant improvements in pain and function in both groups, with larger changes in the Kaltenborn group. When lying on the involved side, 31.6% of participants in the Kaltenborn group reported mild pain (score 1–3), 63.2% reported moderate pain (4–6), and only 5.3% remained in the severe range (7–10) after treatment, whereas a higher proportion of the ROM group continued to report severe pain (23.7%), with 18.4% in mild and 57.9% in moderate categories. Similar patterns were observed for pain when touching the back of the neck, and for disability in washing the back and placing objects on a high shelf, with the Kaltenborn group shifting more participants into lower pain and disability categories than the ROM group. These categorical improvements are reflected in the mean change scores presented in Table 1.

Within-group analyses based on SPADI item-level change scores showed that the Kaltenborn glides plus ultrasound group experienced large and statistically significant reductions in pain and disability. Mean change in pain when lying on the involved side was 1.11 (SD 0.57), with a 95% CI from 0.83 to 1.38 and a large effect size (d=1.95; p<0.001). Pain during touching the back of the neck decreased by a mean of 1.00 (SD 0.67; 95% CI 0.68 to 1.32; d=1.50; p<0.001). Disability scores for washing the back and placing an object on a high shelf improved by 0.89 (SD 0.32; 95% CI 0.74 to 1.05; d=2.84; p<0.001) and 0.95 (SD 0.62; 95% CI 0.65 to 1.25; d=1.52; p<0.001), respectively. In contrast, the ROM exercises plus ultrasound group exhibited smaller but still statistically significant improvements across SPADI items: mean change in pain when lying on the involved side was 0.37 (SD 0.50; 95% CI 0.13 to 0.61; d=0.74; p=0.005), and pain during touching the back of the neck decreased by 0.32 (SD 0.48; 95% CI 0.09 to 0.55; d=0.66; p=0.010). Disability improvements for washing the back and placing objects on a high shelf were 0.21 (SD 0.42; 95% CI 0.01 to 0.41; d=0.50; p=0.042) and 0.32 (SD 0.48; 95% CI 0.09 to 0.55; d=0.66; p=0.010), respectively. These within-group results indicate that both interventions were effective in reducing shoulder pain and disability, but the magnitude of improvement was substantially greater in the Kaltenborn group (Table 1).

Between-group comparisons of SPADI change scores confirmed statistically and clinically superior outcomes for the Kaltenborn glides plus ultrasound protocol. The difference in mean change in pain when lying on the involved side between groups was 0.74 in favour of the Kaltenborn group (standard error (SE) 0.17; 95% CI 0.39 to 1.09; t=4.26; p<0.001). For pain during touching the back of the neck, the between-group difference in mean change was 0.68 (SE 0.19; 95% CI 0.30 to 1.07; t=3.64; p<0.001). Differences in disability improvement were also pronounced: for washing the back, the mean change was greater by 0.68 points in the Kaltenborn group (SE 0.12; 95% CI 0.44 to 0.93; t=5.69; p<0.001), and for placing an object on a high shelf, the difference was 0.63 (SE 0.18; 95% CI 0.27 to 1.00; t=3.51; p<0.001). These findings indicate large between-group effect sizes favouring Kaltenborn mobilization combined with ultrasound for pain and disability outcomes (Table 2).

Goniometric assessment demonstrated substantial gains in shoulder ROM in both groups. In the Kaltenborn group, external rotation improved by a mean of 2.32 degrees (SD 0.48; 95% CI −2.55 to −2.09, reflecting increased range given the direction of scoring; |d|=4.85; p<0.001), and abduction improved by 2.26 degrees (SD 0.45; 95% CI −2.48 to −2.05; |d|=5.00; p<0.001). In the ROM group, mean improvements in external rotation and abduction were 2.53 degrees (SD 0.61; 95% CI −2.82 to −2.23; |d|=4.13; p<0.001) and 2.16 degrees (SD 0.50; 95% CI −2.40 to −1.92; |d|=4.30; p<0.001), respectively. These large effect sizes demonstrate that both interventions were highly effective in restoring glenohumeral mobility over the study period (Table 1).

Between-group comparisons of ROM change scores showed no statistically significant differences between the Kaltenborn and ROM groups. The difference in mean change in external rotation was 0.21 degrees (SE 0.18; 95% CI −0.15 to 0.57; t=1.18; p=0.24), and for abduction the difference was −0.11 degrees (SE 0.16; 95% CI −0.42 to 0.21; t=−0.68; p=0.50), indicating that both treatment strategies produced comparable gains in shoulder abduction and external rotation (Table 2). Thus, the principal advantage of the Kaltenborn glides plus ultrasound protocol over ROM exercises plus ultrasound was in pain relief and disability reduction rather than additional ROM gains.

Table 1. Within-group changes in SPADI item scores and shoulder ROM after intervention in diabetic adhesive capsulitis (n=19 per group)

Outcome	Group	Mean change*	SD of change	95% CI	Cohen's d	p-value†
SPADI: pain lying on involved side	Kaltenborn glides + US	1.11	0.57	0.83 to 1.38	1.95	<0.001
	ROM exercises + US	0.37	0.50	0.13 to 0.61	0.74	0.005
SPADI: pain touching back of neck	Kaltenborn glides + US	1.00	0.67	0.68 to 1.32	1.50	<0.001
	ROM exercises + US	0.32	0.48	0.09 to 0.55	0.66	0.010
SPADI: disability washing back	Kaltenborn glides + US	0.89	0.32	0.74 to 1.05	2.84	<0.001
	ROM exercises + US	0.21	0.42	0.01 to 0.41	0.50	0.042
SPADI: disability placing object on high shelf	Kaltenborn glides + US	0.95	0.62	0.65 to 1.25	1.52	<0.001
	ROM exercises + US	0.32	0.48	0.09 to 0.55	0.66	0.010
External rotation (degrees)	Kaltenborn glides + US	−2.32	0.48	−2.55 to −2.09	−4.85	<0.001
	ROM exercises + US	−2.53	0.61	−2.82 to −2.23	−4.13	<0.001
Abduction (degrees)	Kaltenborn glides + US	−2.26	0.45	−2.48 to −2.05	−5.00	<0.001
	ROM exercises + US	−2.16	0.50	−2.40 to −1.92	−4.30	<0.001

*Mean change is post-treatment minus baseline; positive values for SPADI items indicate reduction in pain/disability, whereas negative values for ROM reflect increased range due to scoring direction. †p-values from paired t-tests within each group.

Table 2. Between-group comparison of change scores for SPADI items and shoulder ROM (Kaltenborn glides + US minus ROM exercises + US)

Outcome	Difference in mean change*	SE	95% CI for difference	t-value	p-value†
SPADI: pain lying on involved side	0.74	0.17	0.39 to 1.09	4.26	<0.001
SPADI: pain touching back of neck	0.68	0.19	0.30 to 1.07	3.64	<0.001
SPADI: disability washing back	0.68	0.12	0.44 to 0.93	5.69	<0.001
SPADI: disability placing object on high shelf	0.63	0.18	0.27 to 1.00	3.51	<0.001
External rotation (degrees)	0.21	0.18	−0.15 to 0.57	1.18	0.24
Abduction (degrees)	−0.11	0.16	−0.42 to 0.21	−0.68	0.50

*Positive values favour Kaltenborn glides + ultrasound. †p-values from independent-samples t-tests comparing change scores between groups.

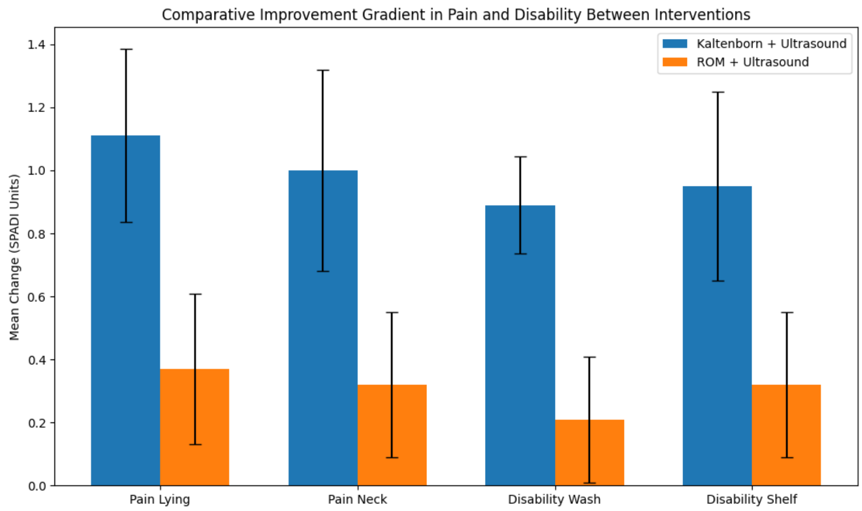

Figure 1 The figure illustrates a pronounced and clinically meaningful improvement gradient favoring the Kaltenborn + ultrasound intervention across all SPADI pain and disability domains. Mean reductions in pain while lying on the involved side (1.11 vs. 0.37 units) and during neck-reaching movements (1.00 vs. 0.32 units) exceeded those of the ROM + ultrasound group by margins of 0.74

and 0.68 units, respectively, with non-overlapping 95% confidence intervals suggesting robust treatment separation. Functional disability outcomes displayed an even wider divergence, with improvements in washing the back (0.89 vs. 0.21 units) and reaching to a high shelf (0.95 vs. 0.32 units) showing three- to fourfold superiority. The consistent vertical distance between groups, combined with the narrower confidence dispersion in the Kaltenborn arm, indicates both greater efficacy and more reliable clinical response. These patterns underscore the substantial additive value of joint gliding mobilization when paired with ultrasound, yielding a higher therapeutic impact on pain-modulated functional tasks that are often the most limiting for patients with diabetic adhesive capsulitis.

DISCUSSION

The present randomized controlled trial investigated the comparative effectiveness of two common physiotherapy strategies for diabetic adhesive capsulitis—ultrasound combined with Kaltenborn shoulder glides versus ultrasound combined with range of motion exercises—and demonstrated that both interventions yielded statistically and clinically significant improvements in shoulder pain, disability, and ROM. However, the magnitude of improvement in SPADI pain and disability items was consistently greater in the Kaltenborn glides plus ultrasound group, whereas gains in abduction and external rotation were large and comparable across groups. These findings support the primary hypothesis that adjunctive joint mobilization confers additional benefit in symptom relief over a structured ROM exercise programme when both are delivered with therapeutic ultrasound in diabetic frozen shoulder, although the treatments appear similarly efficacious in restoring glenohumeral mobility.

Our results align with the broader literature describing adhesive capsulitis as a condition characterised by capsular contracture, collagen thickening, and progressive restriction of motion, particularly in elevation and external rotation (1–5). The demographic profile of the sample, with a predominance of women and individuals aged 55–65 years, mirrors reported epidemiology and reinforces the relevance of the population studied (2,4,5). The strong association between diabetes and frozen shoulder observed in this cohort is consistent with previous reports documenting a higher prevalence and more refractory course of adhesive capsulitis in diabetic individuals, likely mediated by prolonged hyperglycaemia and advanced glycation end-products within capsular collagen (2,5). Our findings therefore add context-specific evidence from a South Asian setting to a body of work predominantly derived from higher-income health systems (2,4,5,8).

The superior pain and disability outcomes observed in the Kaltenborn group are plausibly explained by the mechanistic rationale of combining deep heating with targeted joint mobilisation. Therapeutic ultrasound, when applied with appropriate parameters, has been shown to increase tissue temperature, blood flow, and collagen extensibility, as well as to modulate inflammatory processes and pain perception (9–15). Experimental studies have confirmed that continuous ultrasound at 1–3 MHz can produce meaningful temperature rises at depths relevant to periarticular tissues, supporting its use as a deep heating modality in stiff, fibrotic joints (13–15). In our protocol, ultrasound was delivered immediately before or alongside Kaltenborn mobilizations, which are designed to apply graded traction and translational glides parallel or perpendicular to the joint surface in accordance with the convex–concave rule to reduce pain, stretch the capsule, and restore accessory motion (5,17,29–31). It is reasonable to hypothesize that pre-heated capsular tissues respond more favourably to mobilisation, resulting in greater pain relief and functional gains than when ultrasound is followed only by ROM exercises.

Previous evidence regarding ultrasound in adhesive capsulitis has been mixed. Some controlled trials and systematic reviews have suggested that ultrasound alone is not clearly superior to sham or placebo, particularly when used in isolation without intensive stretching or mobilisation (16,17,23,24). Dogru et al. and others have reported improvements in pain and ROM with ultrasound but questioned whether these benefits exceed those of placebo when confounding factors are controlled (16,24). Conversely, studies combining ultrasound with exercise or manual therapy have tended to show more favourable outcomes, supporting the concept that ultrasound may function optimally as an adjunct to mechanical interventions rather than as a stand-alone treatment (16,17,23,24,29,30). Our findings are congruent with this integrative view, demonstrating that both ultrasound-based protocols were effective, but that the addition of joint glides produced superior improvements in patient-reported pain and disability.

The large and comparable gains in ROM across both groups are also consistent with prior literature emphasising the central role of stretching, active use, and repeated loading in restoring glenohumeral motion (4,5,17,23,24). ROM exercises—whether passive, active-assisted, or active—promote capsular elongation, neuromuscular re-education, and functional integration, and are widely recommended in clinical practice guidelines (4,5,17). In this trial, both groups received structured ROM work: directly in the ROM group and indirectly in the Kaltenborn group, where mobilization likely facilitated subsequent voluntary movement. The absence of a between-group difference in ROM gains suggests that, over the time frame studied, both approaches are capable of producing substantial improvements in abduction and external rotation in diabetic adhesive capsulitis. However, the greater reduction in pain and disability with Kaltenborn mobilization has important clinical implications, as symptom relief and functional recovery are often more meaningful to patients than absolute range values.

The present findings also resonate with comparative manual therapy studies that have evaluated different mobilisation paradigms in adhesive capsulitis and related shoulder disorders. Work comparing Kaltenborn and Mulligan techniques, as well as studies on posterior versus anterior glides, has generally shown that joint mobilization can significantly improve pain and ROM, though superiority of one technique over another is not always evident (17,29–31). In particular, posterior glides have been reported to be more effective than anterior glides in improving external rotation in adhesive capsulitis, underscoring the importance of respecting joint arthrokinematics when selecting mobilisation directions (29–31). Our study did not directly compare alternative manual therapy schools, but the favourable outcomes associated with Kaltenborn glides support their inclusion as a viable and effective component of multimodal rehabilitation in this population.

From a practical standpoint, the data suggest that in busy public-sector physiotherapy services treating diabetic patients with frozen shoulder, a protocol combining therapeutic ultrasound with Kaltenborn shoulder glides may offer an efficient means to achieve greater pain relief and functional improvement without sacrificing ROM gains. For clinicians with established manual therapy skills, this approach may be particularly attractive for patients presenting with high pain levels and prominent capsular end-feel. However, structured ROM exercise programmes remain effective and may be more feasible where manual therapy resources are limited or where patient preference favours self-directed exercise. The comparable ROM improvements across groups reinforce that both strategies can be used to restore movement, and treatment decisions may therefore be guided by therapist expertise, patient characteristics, resource availability, and response to initial sessions.

This study has several limitations that should be considered when interpreting the results. The sample size was modest, with 19 participants per group, which may limit the precision of effect estimates and the ability to detect smaller between-group differences, particularly for ROM outcomes. The study was conducted in government hospitals within a single city, which may constrain generalisability to other regions or health system contexts, including rural areas or private practice settings. The follow-up period was confined to immediate post-treatment assessments; longer-term outcomes beyond the intervention phase were not captured, and it is therefore unclear whether the observed benefits, especially in pain and disability, are sustained over months, which is a key concern in a condition with a typically protracted course (1–5,8). Blinding of participants and therapists to intervention allocation was not feasible and may introduce performance or expectancy bias, although objective goniometric measurements and a standardised SPADI protocol help mitigate this risk (22). In addition, potential confounders such as glycaemic control, duration of diabetes, and comorbid musculoskeletal conditions were not formally stratified or adjusted for, which could influence responsiveness to treatment (2,5).

Nevertheless, the study also has notable strengths. It focuses specifically on diabetic individuals with idiopathic adhesive capsulitis, a clinically important subgroup that is underrepresented in many trials (2,5,8). The randomised design with clearly defined interventions and standardized outcome measures, including a validated shoulder-specific index and objective ROM assessment, enhances internal validity (1–5,22). The use of routine clinical settings in government hospitals increases the external relevance of the findings for real-world practice in similar resource-constrained environments. By directly comparing two widely used physiotherapy protocols that share a common physical agent but differ in the adjunctive manual versus exercise component, the trial provides pragmatic guidance for treatment planning and resource allocation in diabetic frozen shoulder rehabilitation (4,5,16,17,23,24,29–31). Future research should build on these findings by incorporating larger multi-centre samples, longer-term follow-up, stratification by diabetes-related factors, and comparison with other emerging modalities or combined programmes, including home-based and self-mobilization strategies, to optimise outcomes across diverse patient groups (4,5,16–18,23,24,29–31).

CONCLUSION

In conclusion, this randomized controlled study shows that both ultrasound combined with Kaltenborn shoulder glides and ultrasound combined with ROM exercises significantly improve pain, disability, and shoulder ROM in diabetic patients with adhesive capsulitis, with the Kaltenborn protocol providing superior reductions in pain and functional limitation while achieving ROM gains comparable to those of the exercise-based protocol. These data support the use of manual joint mobilization in conjunction with deep heating modalities as a preferred option when the primary therapeutic goals are rapid pain relief and functional recovery in this high-risk population.

The findings of this trial indicate that among diabetic adults with idiopathic adhesive capsulitis, both ultrasound-based rehabilitation programmes are effective in enhancing shoulder function, but adding Kaltenborn joint glides to therapeutic ultrasound yields greater improvement in pain and disability without compromising ROM outcomes, suggesting that manual mobilisation should be considered a key component of multimodal conservative management for diabetic frozen shoulder in comparable clinical settings.

REFERENCES

1. Neviaser AS, Neviaser RJ. Adhesive capsulitis of the shoulder. J Am Acad Orthop Surg. 2011;19(9):536–42.

2. Le HV, Lee SJ, Nazarian A, Rodriguez EK. Adhesive capsulitis of the shoulder: review of pathophysiology and current clinical treatments. Shoulder Elbow. 2017;9(2):75–84.

3. Walmsley S, Rivett DA, Osmotherly PG. Adhesive capsulitis: establishing consensus on clinical identifiers for stage 1 using the Delphi technique. Phys Ther. 2009;89(9):906–17.

4. Kelley MJ, Shaffer MA, Kuhn JE, Michener LA, Seitz AL, Uhl TL, et al. Shoulder pain and mobility deficits: adhesive capsulitis: clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. J Orthop Sports Phys Ther. 2013;43(5 Suppl):A1–31.

5. Manske RC, Prohaska D. Diagnosis and management of adhesive capsulitis. Curr Rev Musculoskelet Med. 2008;1(3–4):180–9.

6. Carbone S, Gumina S, Vestri AR, Postacchini R. Coracoid pain test: a new clinical sign of shoulder adhesive capsulitis. Int Orthop. 2010;34(3):385–8.

7. Tyree KA, May J. A novel approach to treatment utilizing breathing and a total motion release® exercise program in a high school cheerleader with a diagnosis of frozen shoulder: a case report. Int J Sports Phys Ther. 2018;13(5):905–15.

8. Sharma S, Jacobs L. Management of frozen shoulder–conservative vs surgical? Ann R Coll Surg Engl. 2011;93(5):343–4.

9. Heinrichs K. Superficial thermal modalities. In: Millis DL, Levine D, Taylor RA, editors. Canine rehabilitation and physical therapy. St Louis: Saunders Elsevier; 2004. p. 291–309.

10. Chen WS, Annaswamy TM, Yang W, Wang TG, Kwon DR, Chou LW. Physical agent modalities. In: Cifu DX, editor. Braddom's physical medicine and rehabilitation. 6th ed. Amsterdam: Elsevier; 2021. p. 338–63.e6.

11. Nanneman D. Thermal modalities: heat and cold: a review of physiologic effects with clinical applications. AAOHN J. 1991;39(2):70–5.

12. Fischer E, Solomon S. Physiological responses to heat and cold. In: Licht S, editor. Therapeutic heat and cold. 2nd rev ed. Vol. 2. New Haven (CT): E. Licht; 1965. p. 126–69.

13. Draper DO, Castel JC, Castel D. Rate of temperature increase in human muscle during 1 MHz and 3 MHz continuous ultrasound. J Orthop Sports Phys Ther. 1995;22(4):142–50.

14. O'Brien WD Jr. Ultrasound–biophysics mechanisms. Prog Biophys Mol Biol. 2007;93(1–3):212–55.

15. Hayes BT, Merrick MA, Sandrey MA, Cordova ML. Three-megahertz ultrasound heats deeper into the tissues than originally theorized. J Athl Train. 2004;39(3):230–4.

16. Page MJ, Green S, Kramer S, Johnston RV, McBain B, Buchbinder R. Electrotherapy modalities for adhesive capsulitis (frozen shoulder). Cochrane Database Syst Rev. 2014;2014(10):CD011324.

17. Jason JI, Sundaram GS, Subramani MV. Physiotherapy interventions for adhesive capsulitis of shoulder: a systematic review. Int J Physiother Res. 2015;3(3):1318–25.

18. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4:1.

19. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health. 1998;52(6):377–84.

20. Lien-Iversen T, Morgan DB, Jensen C, Risberg MA, Engebretsen L, Viberg B. Does surgery reduce knee osteoarthritis, meniscal injury and subsequent complications compared with non-surgery after ACL rupture with at least 10 years follow-up? A systematic review and meta-analysis. Br J Sports Med. 2020;54(10):592–8.

21. Fleiss JL. Measuring nominal scale agreement among many raters. Psychol Bull. 1971;76(5):378–82.

22. Williams JW Jr, Holleman DR Jr, Simel DL. Measuring shoulder function with the Shoulder Pain and Disability Index. J Rheumatol. 1995;22(4):727–32.

23. Kothari SY, Venkataraman Srikumar NS. Comparative efficacy of platelet rich plasma injection, corticosteroid injection and ultrasonic therapy in the treatment of periarthritis shoulder. J Clin Diagn Res. 2017;11(5):RC15–8.

24. Balci TO, Turk AC, Sahin F, Kotevoglu N, Kuran B. Efficacy of therapeutic ultrasound in treatment of adhesive capsulitis: a prospective double blind placebo-controlled randomized trial. J Back Musculoskelet Rehabil. 2018;31(5):955–61.

25. Gu S, Shi J, Tang Z, Sawhney M, Hu H, Shi L, et al. Comparison of glucose lowering effect of metformin and acarbose in type 2 diabetes mellitus: a meta-analysis. PLoS One. 2015;10(5):e0126704.

26. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al., editors. Cochrane handbook for systematic reviews of interventions. Hoboken (NJ): John Wiley & Sons; 2019.

27. Zlowodzki M, Poolman RW, Kerkhoffs GM, Tornetta P 3rd, Bhandari M; International Evidence-Based Orthopedic Surgery Working Group. How to interpret a meta-analysis and judge its value as a guide for clinical practice. Acta Orthop. 2007;78(5):598–609.

28. Wang J, Mannen EM, Siddicky SF, Lee JM, Latt LD. Gait alterations in posterior tibial tendonitis: a systematic review and meta-analysis. Gait Posture. 2020;76:28–38.

29. Gaba E, Sethi J, Bhardwaj M. Effect of interferential therapy over ultrasound therapy with common protocol of manual therapy in grade-II frozen shoulder. J Exerc Sci Physiother. 2020;16(2):23–31.

30. Sonal C, Kothari S, Nonica L. Comparison of ultrasonic therapy, sodium hyaluronate injection and steroid injection in the treatment of peri-arthritis shoulder. Indian J Phys Med Rehabil. 2012;23(3):105–10.

31. Kumar R, Bansal N, Sidhu A. An observational study to compare the outcome of local steroid injections and ultrasonic wave therapy in frozen shoulder patients. Int J Orthop. 2018;4(1):98–101.