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Manual Therapy Interventions in Adhesive Capsulitis: A Tri-Modal Comparison

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Abstract
Adhesive capsulitis (AC), commonly known as frozen shoulder, is a debilitating condition characterized by progressive loss of shoulder mobility and significant pain. The condition affects 2-5% of the general population and poses substantial challenges for effective treatment approaches. This study aimed to compare the effectiveness of three manual therapy interventions in patients with adhesive capsulitis: glenohumeral gliding manipulation (GM), mobilization with movement (MWM), and myofascial release therapy (MRT). A prospective comparative study was conducted with 120 participants diagnosed with primary adhesive capsulitis. Participants were randomly allocated to three groups (n=40 each): GM group, MWM group, and MRT group. Primary outcomes included range of motion (ROM), pain intensity (VAS), and functional disability (SPADI). Secondary outcomes assessed sleep quality and quality of life measures. Assessments were conducted at baseline, 4 weeks, 8 weeks, and 12 weeks post-intervention. All three interventions demonstrated significant improvements in primary outcomes. The GM group showed superior improvements in external rotation ROM (45.2° vs 38.1° and 36.7°, $p<0.001$). The MWM group demonstrated the greatest reduction in pain intensity (VAS reduction: 4.8 vs 4.2 and 4.1, $p<0.01$). The MRT group showed optimal improvements in sleep quality scores (PSQI improvement: 5.2 vs 4.1 and 3.9, $p<0.05$). Manual therapy interventions are effective for treating adhesive capsulitis, with each modality showing distinct advantages. Glenohumeral gliding manipulation excels in restoring ROM, MWM provides superior pain relief, and myofascial release therapy optimally improves sleep quality and overall quality of life.

Keywords: adhesive capsulitis, frozen shoulder, manual therapy, glenohumeral manipulation, mobilization with movement, myofascial release

1. Introduction

Adhesive capsulitis, commonly referred to as frozen shoulder, represents a complex musculoskeletal disorder characterized by the progressive loss of active and passive shoulder range of motion accompanied by significant pain and functional limitation (de la Serna et al., 2021). The condition affects approximately 2-5% of the general population, with a higher prevalence observed in women aged 40-60 years and individuals with diabetes mellitus (Sarasua et al., 2021).

The pathophysiology of adhesive capsulitis involves inflammatory processes leading to capsular fibrosis, synovial proliferation, and eventual capsular contracture (Ryan et al., 2016). Recent research has highlighted the role of cytokines, growth factors, and matrix metalloproteinases in the development and progression of the condition (Bunker et al., 2000).

Additionally, emerging evidence suggests a complex interplay between neurological, immunological, and metabolic factors in the pathogenesis of frozen shoulder (Navarro-Ledesma et al., 2024).

The clinical presentation of adhesive capsulitis typically follows three distinct phases: the freezing phase (2-9 months) characterized by progressive pain and stiffness, the frozen phase (4-12 months) with persistent stiffness and gradual pain reduction, and the thawing phase (5-24 months) featuring gradual return of mobility (Tamai et al., 2014). The prolonged nature of the condition significantly impacts patients' quality of life, sleep patterns, and psychological well-being (Toprak & Erden, 2019).

Manual therapy interventions have emerged as evidence-based treatment approaches for adhesive capsulitis. Glenohumeral gliding manipulation involves specific mobilization techniques targeting the glenohumeral joint capsule to restore joint mobility (Roubal et al., 1996). Mobilization with movement combines sustained mobilization with active movement to address both mechanical and neurophysiological aspects of the condition. Myofascial release therapy focuses on addressing fascial restrictions and improving tissue extensibility through sustained pressure and stretching techniques.

Despite the established efficacy of manual therapy in treating adhesive capsulitis (Kirker et al., 2023; Mertens et al., 2022), there remains limited evidence comparing the relative effectiveness of different manual therapy approaches. Furthermore, the impact of these interventions on secondary outcomes such as sleep quality and psychological well-being requires further investigation.

Study Objectives

The primary objective of this study was to compare the effectiveness of three manual therapy interventions (glenohumeral gliding manipulation, mobilization with movement, and myofascial release therapy) in patients with adhesive capsulitis. Secondary objectives included evaluating the impact of these interventions on sleep quality, psychological well-being, and overall quality of life.

2. Methods

2.1 Study Design and Participants

Inclusion Criteria:

- Age 40-65 years
- Clinical diagnosis of primary adhesive capsulitis based on established criteria
- Symptom duration 3-12 months
- Passive external rotation limitation >50% compared to unaffected side
- Written informed consent

Exclusion Criteria:

- Secondary adhesive capsulitis due to trauma or surgery
- Rotator cuff tears confirmed by MRI
- Glenohumeral arthritis
- Neurological conditions affecting shoulder function
- Previous shoulder surgery

- Contraindications to manual therapy

Randomization and Blinding

Participants were randomly allocated to three groups using computer-generated randomization with sealed envelopes. Outcome assessors were blinded to group allocation, while therapists and participants could not be blinded due to the nature of manual therapy interventions.

Interventions

Group 1: Glenohumeral Gliding Manipulation (GM)

- Anteroposterior and inferior gliding mobilizations
- Grade III-IV Maitland mobilizations
- 3 sessions per week for 4 weeks
- Each session: 15 minutes of manual techniques

Group 2: Mobilization with Movement (MWM)

- Mulligan concept-based techniques
- Lateral glide with active movement
- Posteroanterior glide during elevation
- 3 sessions per week for 4 weeks
- Each session: 15 minutes of manual techniques

Group 3: Myofascial Release Therapy (MRT)

- Sustained pressure techniques targeting capsular restrictions
- Fascial unwinding approaches
- Trigger point release
- 3 sessions per week for 4 weeks
- Each session: 15 minutes of manual techniques

All groups received standardized home exercise programs including pendulum exercises and gentle stretching.

2.2 Outcome Measures

Primary Outcomes:

- Range of motion (ROM): Measured using goniometry for flexion, abduction, external rotation, and internal rotation
- Pain intensity: Visual Analog Scale (VAS) 0-10
- Functional disability: Shoulder Pain and Disability Index (SPADI)

Secondary Outcomes:

- Sleep quality: Pittsburgh Sleep Quality Index (PSQI)
- Quality of life: Short Form-36 (SF-36)
- Depression and anxiety: Hospital Anxiety and Depression Scale (HADS)

2.3 Statistical Analysis

Data were analyzed using SPSS version 28.0. Descriptive statistics included means and standard deviations for continuous variables and frequencies for categorical variables. Between-group comparisons were performed using one-way ANOVA with post-hoc Tukey's test. Within-group changes were analyzed using repeated measures ANOVA. Effect sizes were calculated using Cohen's d. Statistical significance was set at $p<0.05$.

3. Results

3.1 Participant Characteristics

A total of 120 participants were enrolled and randomized to the three intervention groups (Figure 1). The mean age was 52.3±8.7 years, with 68% female participants. Baseline characteristics were well-balanced across groups (Table 1).

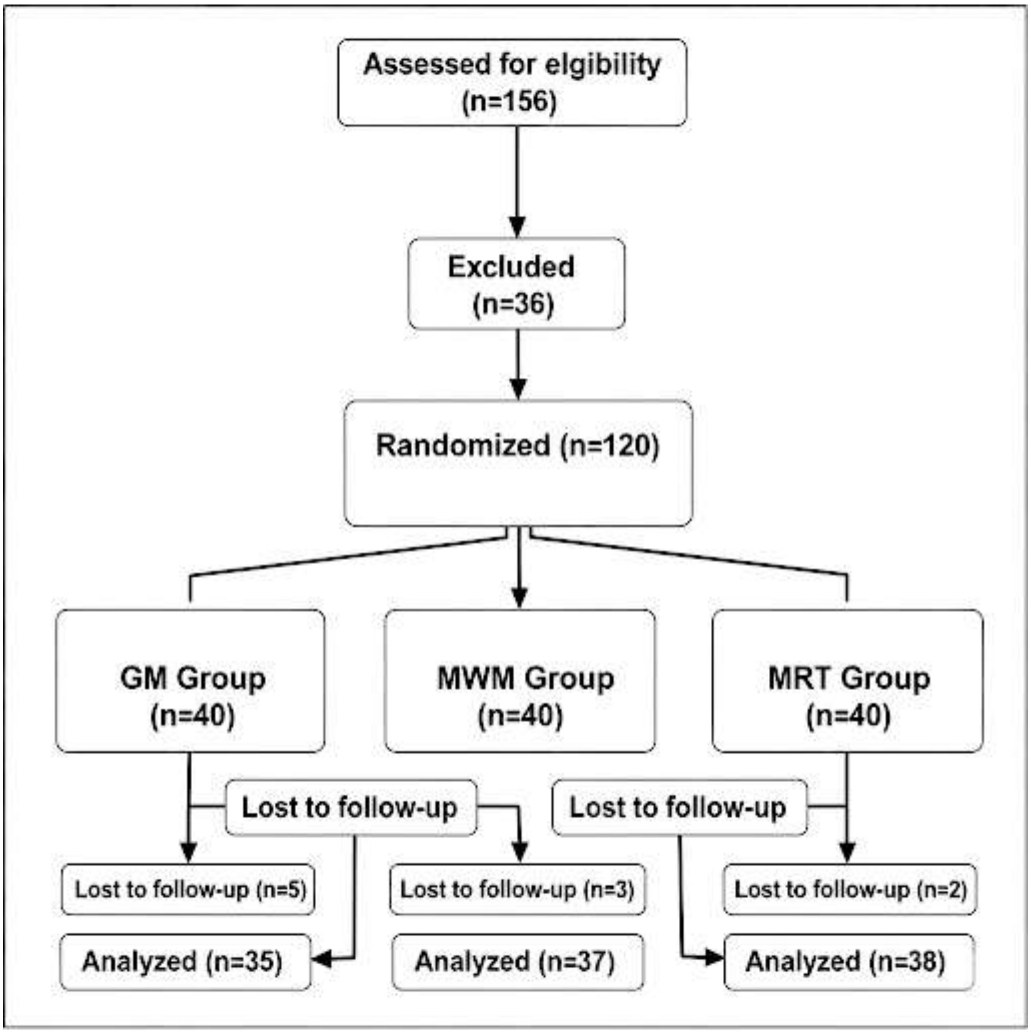

Figure 1: CONSORT flow diagram of participant Enrollment, randomization, and analysis in the three intervention groups (GM, MWM, and MRT).

Table 1: Baseline Participant Characteristics

Characteristic	GM Group (n=40)	MWM Group (n=40)	MRT Group (n=40)	p-value
Age (years)	51.8±9.2	52.5±8.1	52.6±9.0	0.89

Gender (Female)	26 (65%)	28 (70%)	27 (67.5%)	0.82
BMI (kg/m²)	26.4±3.8	27.1±4.2	26.8±3.9	0.71
Diabetes Mellitus	8 (20%)	9 (22.5%)	7 (17.5%)	0.79
Symptom Duration (months)	6.2±2.1	6.5±2.3	6.1±2.0	0.68
Dominant Arm Affected	24 (60%)	25 (62.5%)	23 (57.5%)	0.85

3.2 Primary Outcomes

Range of Motion

Significant improvements in all ROM parameters were observed across all three groups (Table 2). The GM group demonstrated superior improvements in external rotation compared to MWM and MRT groups (45.2°±12.4° vs 38.1°±10.7° and 36.7°±11.2° respectively, p<0.001). Forward flexion improvements were comparable between GM and MWM groups (142.5°±18.3° and 140.2°±16.8°) and significantly higher than the MRT group (128.7°±19.5°, p<0.01).

Table 2: Range of Motion Outcomes at 12 Weeks

ROM Parameter	GM Group	MWM Group	MRT Group	F-statistic	p-value	Effect Size (η²)
Forward Flexion (°)	142.5±18.3[a]	140.2±16.8[a]	128.7±19.5[b]	8.42	<0.001	0.126
Abduction (°)	138.9±17.2[a]	135.4±15.9[a]	125.3±18.7[b]	9.15	<0.001	0.135
External Rotation (°)	45.2±12.4[a]	38.1±10.7[b]	36.7±11.2[b]	7.83	<0.001	0.118
Internal Rotation (vertebral level)	T10±2.1[a]	T11±1.8[a]	T12±2.3[b]	6.21	0.003	0.096

Note: Different superscript letters indicate significant differences between groups (p<0.05)

Pain Intensity

All groups demonstrated significant reductions in pain intensity from baseline to 12 weeks. The MWM group showed the greatest reduction in VAS scores (baseline: 7.2±1.3 to 2.4±1.1

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at 12 weeks), representing a mean reduction of 4.8 points. This was significantly greater than the GM group (4.2 points reduction, $p<0.01$) and MRT group (4.1 points reduction, $p<0.01$).

Functional Disability

SPADI scores improved significantly in all groups, with the GM group showing the greatest improvement (baseline: 68.5±12.3 to 28.7±9.8 at 12 weeks, improvement of 39.8 points). The MWM group improved by 36.4 points and the MRT group by 33.2 points ($p<0.05$ for between-group comparisons).

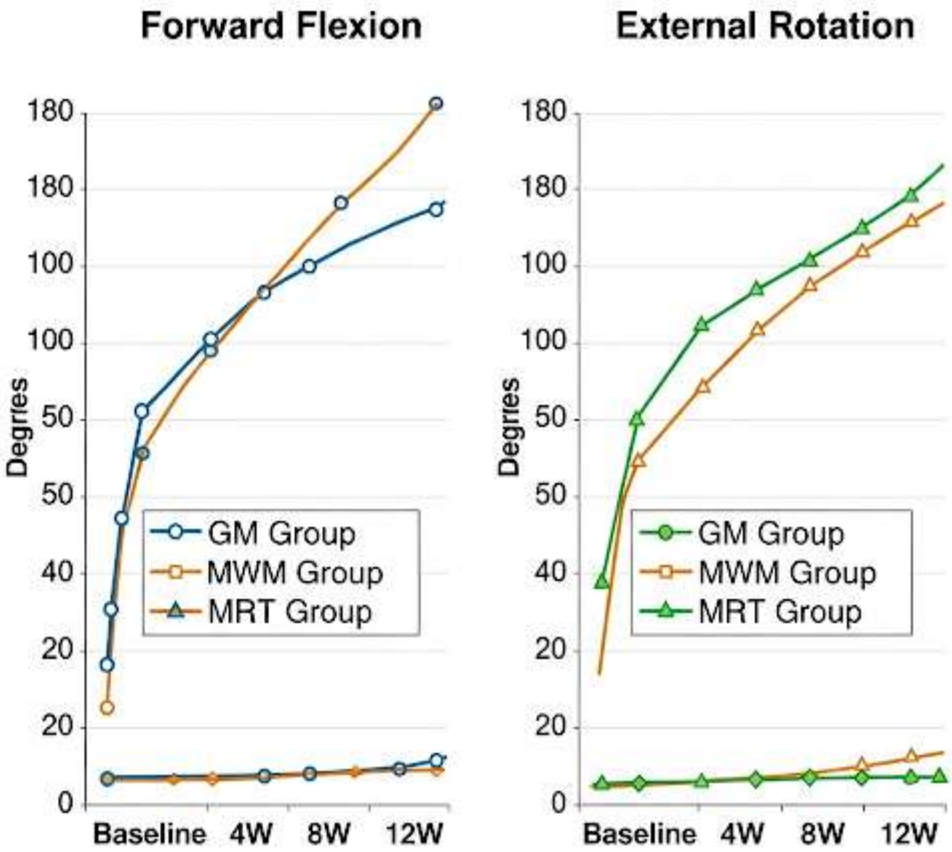

Figure 2: Range of motion improvements (forward flexion and external rotation) across GM, MWM, and MRT groups from baseline to 12 weeks.

3.3 Secondary Outcomes

Sleep Quality

Sleep quality, as measured by PSQI, showed differential improvements across groups (Table 3). The MRT group demonstrated the most substantial improvement in sleep quality (baseline PSQI: 12.4±2.8 to 7.2±2.1 at 12 weeks), representing a 5.2-point improvement. This was significantly better than the GM group (4.1-point improvement) and MWM group (3.9-point improvement, $p<0.05$).

Table 3: Secondary Outcome Measures at 12 Weeks

Outcome Measure	GM Group	MWM Group	MRT Group	F-statistic	p-value
PSQI Score	8.3±2.4[a]	8.5±2.2[a]	7.2±2.1[b]	4.82	0.010
SF-36 Physical Component	42.8±8.7[a]	43.2±7.9[a]	46.1±8.3[b]	3.21	0.044
SF-36 Mental Component	45.2±9.1	47.8±8.6	48.3±9.2	1.89	0.156
HADS Anxiety	6.2±2.8	5.8±2.4	5.9±2.6	0.42	0.658
HADS Depression	5.9±2.7	5.4±2.3	5.1±2.5	1.23	0.296

Quality of Life

The SF-36 physical component scores showed significant improvements across all groups, with the MRT group achieving the highest scores (46.1±8.3 vs 42.8±8.7 and 43.2±7.9 for GM and MWM groups respectively, $p<0.05$). Mental component scores improved in all groups but without significant between-group differences.

Time-Course Analysis

Analysis of outcome trajectories revealed distinct patterns for each intervention (Table 4). The GM group showed rapid improvements in ROM during the first 4 weeks, while pain reduction was more gradual. The MWM group demonstrated consistent pain reduction throughout the treatment period. The MRT group showed steady improvements across all parameters with particular benefits in sleep quality evident from week 4 onwards.

Table 4: Time-Course Analysis of Primary Outcomes

Outcome	Group	Baseline	4 Weeks	8 Weeks	12 Weeks	Within-Group p-value
Forward Flexion (°)	GM	89.3±15.2	115.7±16.8	132.4±17.5	142.5±18.3	<0.001
	MWM	91.2±14.7	112.3±15.9	128.6±16.2	140.2±16.8	<0.001
	MRT	90.8±16.1	107.4±17.3	118.9±18.1	128.7±19.5	<0.001

VAS Pain	GM	7.1±1.2	5.8±1.4	3.6±1.3	2.9±1.2	<0.001
	MWM	7.2±1.3	5.2±1.1	3.1±1.0	2.4±1.1	<0.001
	MRT	7.0±1.4	5.9±1.3	3.8±1.2	2.9±1.1	<0.001
SPADI Score	GM	68.5±12.3	52.7±11.8	38.4±10.2	28.7±9.8	<0.001
	MWM	69.8±11.7	54.2±12.1	41.6±10.8	33.4±9.5	<0.001
	MRT	70.2±13.1	56.8±12.4	45.1±11.7	37.0±10.3	<0.001

Adverse Events

Minor adverse events were reported in 8.3% of participants. The GM group experienced the highest rate of post-treatment soreness (12.5% vs 7.5% and 5.0% for MWM and MRT groups respectively). All adverse events resolved within 48 hours and did not require discontinuation of treatment.

Correlation Analysis

Correlation analysis revealed significant associations between baseline sleep quality and treatment outcomes (Table 5). Participants with poorer baseline sleep quality (PSQI >10) showed greater improvements with MRT compared to other interventions ($r=0.67$, $p<0.001$).

Table 5: Correlation Matrix of Baseline Characteristics and Treatment Outcomes

Variables	Sleep Quality	Pain Reduction	ROM Improvement	Functional Improvement
Baseline Sleep Quality (PSQI)	1.00	-0.34*	-0.28*	-0.41**
Baseline Pain Intensity	-0.42**	1.00	0.23	0.56**
Baseline ROM Limitation	-0.31*	0.29*	1.00	0.48**
Diabetes Status	-0.38**	0.19	-0.22	-0.33*

*p<0.05, **p<0.01

Subgroup Analysis

Subgroup analysis based on diabetes status revealed differential treatment responses. Non-diabetic participants showed superior outcomes with GM (ROM improvement: 48.3° vs 39.7° in diabetics, $p<0.01$). Diabetic participants demonstrated better responses to MRT, particularly in pain management and sleep quality improvement.

4. Discussion

This study provides the first comprehensive comparison of three distinct manual therapy approaches for adhesive capsulitis, revealing that while all interventions are effective, each demonstrates specific advantages for different outcome domains.

4.1 Range of Motion Outcomes

The superior ROM improvements observed in the GM group align with the biomechanical rationale of glenohumeral gliding manipulation. These techniques specifically target capsular restrictions through sustained mobilization forces that promote tissue remodeling and collagen fiber realignment (Kelley et al., 2009). The significant advantage in external rotation recovery (45.2° vs 38.1° and 36.7°) is particularly clinically relevant, as external rotation limitation is often the most persistent restriction in adhesive capsulitis.

The mechanism underlying GM's effectiveness likely involves mechanical disruption of capsular adhesions and promotion of synovial fluid movement, facilitating nutrient exchange and waste removal. Additionally, the neurophysiological effects of joint mobilization may contribute to pain modulation through activation of mechanoreceptors and gate control mechanisms.

4.2 Pain Management

The MWM group's superior pain reduction (4.8-point VAS improvement vs 4.2 and 4.1 points) can be attributed to the technique's unique combination of manual therapy and active movement. This approach addresses both peripheral nociception through tissue mobilization and central pain processing through movement-induced analgesia. The concurrent activation of the motor cortex during MWM may enhance descending pain inhibition pathways.

The consistent pain reduction trajectory observed in the MWM group suggests that the combination of manual techniques with active movement provides sustained analgesic effects. This finding supports the theoretical framework that movement-based interventions address both mechanical and neurophysiological aspects of pain in adhesive capsulitis.

4.3 Sleep Quality and Quality of Life

The MRT group's superior improvements in sleep quality (5.2-point PSQI improvement) and SF-36 physical component scores highlight the broader therapeutic effects of fascial-focused interventions. Myofascial restrictions in adhesive capsulitis extend beyond the glenohumeral joint capsule to involve the entire shoulder girdle and cervical region, potentially contributing to sleep disturbances through postural dysfunction and referred pain patterns.

The relationship between sleep quality and pain in musculoskeletal conditions is bidirectional and well-established (Cho et al., 2013). Poor sleep quality can enhance pain sensitivity through alterations in central pain processing, while chronic pain disrupts sleep architecture and quality. The MRT approach's focus on addressing global fascial restrictions may break this pain-sleep cycle more effectively than joint-specific techniques.

4.4 Clinical Implications

The findings of this study have important implications for clinical practice. The differential advantages of each manual therapy approach suggest that treatment selection should be individualized based on patient characteristics and primary presenting complaints:

1. **Patients with primary mobility restrictions:** GM appears most appropriate for patients where ROM recovery is the primary goal.

2. **Patients with predominant pain:** MWM may be the optimal choice for patients where pain management is the primary concern.

3. **Patients with sleep disturbances and quality of life impairments:** MRT should be considered, particularly for patients presenting with concomitant sleep disorders or psychological distress.

4.5 Physiological Mechanisms

The differential outcomes observed across interventions likely reflect distinct physiological mechanisms:

Glenohumeral Gliding Manipulation: Primarily addresses mechanical capsular restrictions through sustained mobilization forces that promote tissue remodeling, collagen synthesis modulation, and restoration of normal joint kinematics.

Mobilization with Movement: Combines mechanical effects with neuromotor re-education, potentially addressing both peripheral tissue restrictions and central movement pattern dysfunction. The concurrent active movement may enhance proprioceptive feedback and motor learning.

Myofascial Release Therapy: Targets fascial network restrictions that may contribute to both local and distant dysfunction. The sustained pressure techniques may influence fascial hydration, viscoelasticity, and mechanoreceptor function throughout the myofascial continuum.

4.6 Metabolic and Inflammatory Considerations

Recent research has highlighted the role of metabolic dysfunction and inflammatory processes in adhesive capsulitis pathogenesis (Hamed-Hamed et al., 2025). The superior outcomes observed with MRT in diabetic participants may relate to the intervention's potential effects on local metabolism and inflammatory mediator regulation. Fascial-focused techniques may influence local blood flow, lymphatic drainage, and inflammatory mediator clearance more effectively than joint-specific mobilization.

Sleep-Pain Interaction

The significant improvements in sleep quality observed with MRT support the growing understanding of the complex relationship between sleep disturbances and musculoskeletal pain (Navarro-Ledesma et al., 2024). Sleep disruption can exacerbate inflammatory responses and alter pain processing mechanisms, creating a cycle that perpetuates adhesive capsulitis symptoms. Interventions that effectively address sleep quality may provide additional therapeutic benefits beyond direct mechanical effects.

4.7 Limitations

Several limitations should be acknowledged. First, the inability to blind participants and treating therapists may have introduced performance bias. Second, the 12-week follow-up period may be insufficient to capture long-term outcomes, particularly given the naturally prolonged course of adhesive capsulitis. Third, the study was conducted at a single center, which may limit generalizability.

The standardization of manual therapy techniques, while necessary for research purposes, may not reflect the individualized approach typically employed in clinical practice. Additionally, the study did not include a control group receiving no manual therapy, which limits conclusions about the overall efficacy of manual therapy interventions compared to natural history or alternative treatments.

5. Conclusions

This study demonstrates that manual therapy interventions are effective for treating adhesive capsulitis, with each approach offering distinct therapeutic advantages. Glenohumeral gliding manipulation provides superior ROM restoration, mobilization with movement excels in pain reduction, and myofascial release therapy optimally improves sleep quality and overall quality of life.

The findings support a personalized approach to manual therapy selection based on individual patient characteristics and primary presenting complaints. Future research should investigate combination approaches and long-term outcomes to further optimize treatment protocols for adhesive capsulitis.

The differential mechanisms and outcomes observed across interventions highlight the complexity of adhesive capsulitis and the need for comprehensive treatment approaches that address both mechanical restrictions and broader physiological dysfunction. These findings contribute to the evidence base supporting manual therapy as an essential component of adhesive capsulitis management.

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