Effects of Joint Mobilization and Treatment Timing on the Glenohumeral Joint: A Pilot Study

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ABSTRACT

Background & Purpose: To determine if timing of glenohumeral joint mobilizations during treatment sessions has an effect on range of motion and functional outcomes. Joint mobilization is a commonly implemented treatment by physical therapists to increase active and passive range of motion and function. The role that timing of mobilization during treatment plays on range of motion and function, however, is unknown. **Methods:** A convenience sample of 8 subjects who were under the care of licensed physical therapists were recruited and randomly assigned to either an early or late mobilization group. Active and passive range of motion measurements and a subjective functional questionnaire were taken at initial visit, 1-week, and 4-week follow-up. **Findings:** Mann-Whitney U found no statistically significant results. However, the late mobilization group demonstrated a trend toward greater median change for functional outcome measure. **Clinical Relevance & Conclusion:** Timing of joint mobilization did not produce a statistically significant difference in range of motion gains or functional scores. However, individuals receiving mobilization at the end of their treatment appeared to demonstrate a trend toward greater improvements in functional outcome scores. Further research needs to be conducted to confirm this trend.

Key Words: manual therapy, range of motion, function, shoulder

INTRODUCTION

Shoulder pain is a common medical ailment and economic problem that affects 6.9% to 26% of the population at any given time, and can affect up to 66.7% of individuals over a lifetime.[1] Shoulder pain is ranked second only to back pain when looking at the prevalence of musculoskeletal conditions.[2] The importance of devising an efficient and effective treatment plan is crucial in reducing the resultant burdens placed on the individual. Multiple shoulder pathoanatomical dysfunctions can contribute to various types of impairments. These impairments include pain, decreased range of motion (ROM), poor posture, and weakness. All of these conditions can lead to an altered lifestyle. An individual may be limited with reaching overhead, lifting objects, or participating in community and work activities. Because of these limitations, multiple treatment approaches have been devised, ranging from surgical intervention, steroid injection, medication, and physical therapy. Within the realm of physical therapy, a wide variety of interventions can be administered to address the aforementioned impairments, one of which is joint mobilization.[3,4]

The *Guide to Physical Therapist Practice* defines joint mobilization as "a manual therapy technique comprising a continuum of skilled passive movements to the joints or related soft tissues (or both) that are applied at varying speeds and amplitudes, including a small amplitude/high-velocity therapeutic movement."[5] Using manual therapy to mobilize a joint is a skilled technique widely used by therapists today. These mobilizations can be used to treat a number of pathologies and may be applied to any joint throughout the human body. The supposition behind joint mobilization is increased joint mobility, decreased pain, and improved overall function.[6,7] This has been confirmed through a number of studies that have found joint mobilizations to increase ROM,[8,9] increase strength of surrounding muscular tissues,[10] decrease pain,[8,10-14] and improve overall function.[8,10]

Despite favorable evidence regarding joint mobilizations for improving function, there are no standard recommendations regarding which specific joint, type of mobilization, and more importantly, the timing of this manual therapy technique during the treatment session provides the greatest level of improvement.

A recent case series recommended guidelines regarding which exercises and manual therapy techniques can be applied for subacromial impingement syndrome.[2] Researchers found that along with strengthening, joint mobilization to the glenohumeral, scapulothoracic and thoracic joints lead to improvement in function and an overall decrease in symptoms in patients with subacromial impingement syndrome.[2] When treating adhesive capsulitis, clinical practice guidelines recommended joint mobilizations based off of weak evidence to help decrease pain and improve range of motion.[15] In a systematic review, researchers found that although regularly performed, there was not enough high quality evidence to make specific recommendations regarding the effectiveness of joint mobilizations in shoulder pathology.[3] In a recent randomized controlled trial, it was found that conservative treatment combined with manual therapy leads to an improvement in ROM and function along with a decrease in pain in individuals with subacromial impingement syndrome.[8] Finally, in a series of two kinematic studies, it was determined that individuals with shoulder impingement demonstrated increased glenohumeral superior translation, decreased scapular upward rotation, and increased sternoclavicular posterior rotation during arm elevation as compared to asymptomatic individuals.[16,17] These differences further support the use of joint mobilizations as an intervention for individuals with shoulder pain. In each of the cited research, there have been multiple techniques examined and all have shown varying degrees of effectiveness.

One variable that has yet to be examined is the effect that timing of joint mobilizations may have on improvement in ROM, pain, and function. Anecdotal evidence based upon the Physical Stress Theory[18] suggests that if one actively uses a newly gained ROM after mobilization, that patient would maintain greater gains than those who do not continue to stress the newly lengthened tissues.

It was hypothesized that those individuals who received joint mobilizations early in the treatment session would demonstrate

greater long-term ROM improvements as compared to those individuals who received the same treatment at the end of their session. Therefore, the purpose of this pilot study was to investigate the effect of early versus late joint mobilization on improving shoulder ROM in patients with shoulder pathology. Additionally, a secondary outcome for this study was self-reported functional limitation.

METHODS

Design

A prospective, multiple session, repeated measures between subjects design using patients with shoulder pain in an outpatient physical therapy setting.

PARTICIPANTS

The data was collected and participants were recruited by physical therapists (PTs) who were a part of a St. Luke's University Health Network. A total of 10 data collectors aided in data collection, including the authors of this paper. Selection criteria for PTs were as follows: (1) PTs licensed in the state of Pennsylvania, and (2) currently employed by St. Luke's Physical Therapy. Data collectors ranged in years of clinical practice from one to 19 and included 3 current orthopaedic physical therapy residents, one board-certified sports clinical specialist, 5 board-certified orthopaedic clinical specialists, and one fellow of the American Academy of Orthopaedic Physical Therapists.

A convenience sample of consecutive patients presenting for PT consultation with a chief complaint of shoulder problems was recruited from the outpatient physical therapy clinics of St. Luke's Physical Therapy from March 2014 to September 2014. For inclusion and exclusion criteria, see Table 1. Subjects that were found to require referral to another medical professional were provided with the appropriate referral and excluded from the study. Also, those individuals whose symptoms did not originate from the shoulder, were less than 18 years of age, and were unable to complete functional questionnaire were excluded from the study.

INSTRUMENTATION

The Focus On Therapeutic Outcomes (FOTO)[19] scale is a computerized adaptive test (CAT) that is administered using an iPad (iPad 2, Apple, Cupertino, CA), and all PTs have access to this survey at the St. Luke's Physical Therapy clinics. A CAT is a form of test that adapts to the examinee's functional ability level using computer technology and measurement theory to increase the efficiency of the exam process. The CAT has been shown to be a valid measure of function for outpatient physical therapy.[19-21] More specifically, CAT has been shown to demonstrate good construct validity and responsiveness for patients with shoulder complaints.[22,23]

Each participant underwent a physical examination performed by a licensed PT. During this examination, an assessment of active and passive shoulder ROM,[24-26] along with joint mobility of the glenohumeral joint, scapulothoracic joint, thoracic spine, and other indicated joints was performed. Goniometry is the most widely used measurement tool for PTs to determine changes in ROM.[25] This type of measurement has demonstrated fair-good reliability with regards to intra- and interrater reliability (interrater Rho= 0.64-0.69, intrarater Rho=0.53-0.65).[24,27,28] Acceptable intrarater reliability has been found for both standing and supine abduction and external rotation ROM, and supine passive abduction, flexion, and external rotation ROM.[29] Shoulder active ROM was assessed using standard goniometric positioning for shoulder flexion and abduction.[30] Composite internal rotation was performed by having the patient reach behind his back and determine the thumb position on the vertebrae.[31-33] Composite shoulder external rotation was performed by the individual reaching over his head and as far down on the spine as able and then the 3rd digit position on the vertebra was recorded.[34] These methods of assessing active ROM have demonstrated acceptable reliability for all of the aforementioned conditions. Shoulder flexion and functional internal rotation have good intraclass coefficient (ICC) scores (intrarater ICC = 0.62, interrater ICC = 0.65, intrarater ICC = 0.91, interrater ICC = 0.80), respectively. Shoulder composite external rotation has a moderate kappa score (κ = .73). Shoulder abduction and external and internal rotation demonstrated low ICC scores (intrarater ICC = 0.35, interrater not tested; intrarater ICC = 0.43, interrater ICC = 0.11; intrarater ICC = 0.32, interrater ICC = 0.06), respectively.[32,34] Passive ROM was assessed in supine positioning for shoulder flexion, abduction, and internal and external rotation as described by Norkin and White.[30] Internal and external rotation was measured with the arm elevated to 90° of abduction. These methods of measurement have demonstrated good reliability with the intra-examiner ICC values = 0.98, and inter-examiner ICC values that range from 0.87 to 0.89 for shoulder flexion.[26]

PROCEDURES

Physical therapists from 18 St. Luke's Physical Therapy clinics were recruited to collect data from an interoffice memo and through personal discussion with the investigators. Those who agreed to collect data were educated on data collection methods, provided with data collection tools, and the primary investigator maintained regular contact with the data collectors monthly. Interrater reliability of examiners was established prior to commencement of the study

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
≥ 18 years of age	< 18 years of age
20° side to side range of motion difference	Pain or symptoms distal to the elbow
Diagnosis of shoulder pathology	Acute upper extremity fracture
	Glenohumeral joint hypermobility
	PMH of hemiparesis or peripheral nerve injury affecting the upper extremity
	Active/passive cervical range of motion reproduces shoulder pain
	Positive Spurling's test
	Not fluent in English
	Unable to complete Focus on Therapeutic Outcomes (FOTO)

The above table indicates the inclusion and exclusion criteria that were used in the present study.

and found to be within the range of published studies of measurement of shoulder ROM.[24,27,28,31-34] Convenience sampling was used to recruit subjects for this pilot study.

Initial Visit

As a patient at one of the selected outpatient clinics and upon presentation to the initial evaluation for shoulder pathology, the subject was told, "We are currently doing a study to look at when in the session it is best to perform joint mobilizations. No changes to the content of your therapy will be made regardless of participation in this study. Would you be willing to participate?" If the patient declined, the request was logged. If he agreed, the subject was provided with the informed consent form by the primary PT and consent was obtained. The informed consent form was approved by St. Luke's University Health Network's Institutional Review Board prior to initiation of this pilot study. The participant then took the FOTO questionnaire to establish a baseline subjective score. This score was then recorded for later analysis. The FOTO was used to establish demographic values of number of co-morbidities, age, and gender. The primary PT then selected the next research packet that included participate number and assigned group of intervention (Figure 1).

The primary PT then completed the history and screening exam to determine inclusion or exclusion of the subject. Subjects were excluded if they met any of the exclusion criteria in Table 1, which is similar to other studies investigating patients with shoulder pain.[2] Examination findings were then recorded and if he met all inclusion criteria and demonstrated none of the exclusion criteria, the participant continued in the study.

Next, pain patterns were determined and discussed. First, the "at rest" level of pain was established, and then the "at worst" level of pain using the Visual Pain Rating Scale. Pain patterns over the past week were also investigated. Then, a physical therapy examination continued, ensuring that baseline shoulder ROM measurements were obtained. Specifically, shoulder active ROM was assessed using a standard goniometer in a standing position for shoulder flexion (sagittal plane), and abduction (frontal plane).[24] Composite internal rotation of the shoulder complex was assessed by reaching the thumb behind the back and recording the highest spinous process level reached.[25,26] Composite external rotation of the shoulder complex was assessed by reaching over the head and recording the lowest spinous process level reached.

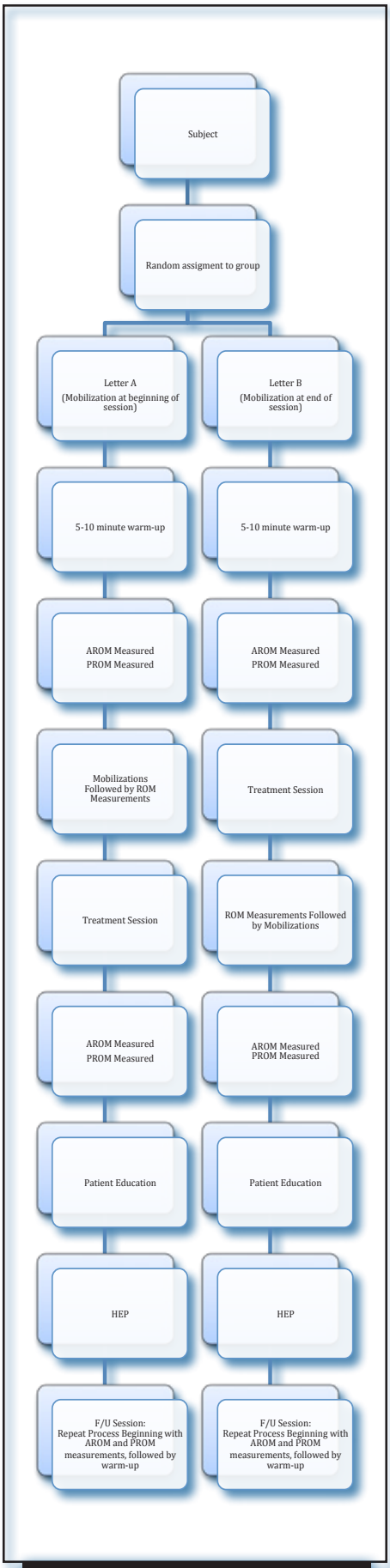

Figure 1. Subject recruitment, flow of initial and follow-up visits.

Passive ROM was measured with a standard goniometer in a supine position, using the methods described by Norkin and White[31] for shoulder flexion (sagittal plane), abduction (frontal plane), and glenohumeral internal and external rotation with shoulder elevated to 90° of abduction. The primary measurements included passive shoulder abduction and external rotation. All other measurements were assessed at initial examination and then at the termination of the study at the 4-week follow-up. After establishing a baseline ROM assessment, the therapist assessed joint mobility of the glenohumeral joint, and associated regions as indicated by the treating therapist. Then, the therapist used her professional judgment to determine which joint mobilization techniques were appropriate for the patient at that time. Those mobilizations may have included inferior, anterior and/or posterior glenohumeral joint mobilizations, posterior-to-anterior thoracic glides or thoracic thrust techniques, posterior-anterior glides, side glides, upper cervical mobilization, and thrust mobilizations for the cervical spine. This is considered a standard of practice and the quality of care was not affected. After initial assessment, the patient was then seen in the clinic for a reassessment of the outcome measurements at week 1 and week 4. On subsequent sessions, the same protocol was followed as the follow-up visits (below), but repeated measurements were not performed.

Follow-up Visits

Follow-up measurements were recorded at 1-week and 4-week time intervals. Follow-up consisted of subjects initially completing the FOTO. The session then began with an active warm up, which consisted of either use of pulleys or an upper body ergometer. After cessation of the active warm-up, depending on the group they were assigned to, joint mobilizations were performed immediately, or at the end of the treatment session. The treatment session consisted of therapeutic and neuromuscular re-education exercises that the authorizing therapist felt appropriate based off of the initial assessment (see Figure 1).

In order for subjects to be eligible for follow-up assessment at 1 week, they were required to have been through a minimum of two treatment sessions within that week. In order for subjects to be eligible for follow up assessment at 4 weeks, they needed to

have participated in a minimum of 6 treatment sessions within those 4 weeks.

If subjects failed to meet the minimum treatment session requirement, they were removed from the study and all subsequent statistical analyses. All data was recorded on a computerized spreadsheet on a secure, password-protected server. All patient information was de-identified.

RESULTS

A total of 31 individuals were screened to participate in the study. Of the 31 screened, 8 individuals met the inclusion criteria and were included in the study (4 males, 4 females, age range 40-89, median age = 64 years) and were randomly assigned to a group. A total of 23 individuals were excluded from the study—3 for having symptoms distal to the elbow, 1 for having an acute upper extremity fracture, 1 secondary cervical motion reproducing shoulder pain, 2 for not being fluent in English, 8 for having acute shoulder surgery, and 8 for having less than a 20° ROM difference between the affected and non-affected side in flexion, abduction, or external rotation.

Both the early mobilization and late mobilization treatment groups had 4 subjects, demographic differences between groups can be seen in Table 2. Each group contained two males and two females, the early mobilization group had a median age of 68 years and the late mobilization group had a median age of 61 years. The acuity of symptoms for each group can be found in Table 3. The early mobilization group had a median fear avoidance score of 18.5 compared to 6.5 of the late mobilization group. When comparing the early mobilization group to the late mobilization group, the median body mass indexes (BMI) were 39.6 and 29.2 respectively. Each group had one subject that chose not to disclose information needed to calculate BMI. The early mobilization group reported a median of 5 co-morbidities on FOTO compared to a median of 5.5 co-morbidities for the late mobilization group.

To test the hypothesis, a Mann-Whitney U test was used to analyze ROM and functional outcomes secondary to having non-parametric data and a small sample size (Table 4). Between groups, there was no statistical significance for active flexion, abduction, internal rotation, or external rotation ($p = .05$, critical value = 1). Furthermore, there was no statistical significance between groups in passive flexion, abduction, or external rotation ranges of motion ($p = .05$, critical value = 1). Median active and passive range of motion scores for the early and late mobilization groups can be found in Table 5. The late mobilization group had greater 4-week functional outcome gains (23 points, range 8-30 points) compared to the early mobilization group (14 points, 9-28 points). Each individual in either group did demonstrate at least an 8-point functional score change. However, these changes were not found to be statistically significant.

Table 2. Patient Demographics

	A	B
Subjects (n)	4	4
Males	2	2
Females	2	2
Median age (range)	68 (54-89)	61 (40-72)

Above demonstrated the demographic break down between the two different groups, A=early mobilization, B=late mobilization.

Table 3. Symptom Acuity

Group	8-14 days	22-90 days	91 days-6 months
A	2 subjects	2 subjects	0 subjects
B	1 subject	1 subject	2 subjects

Above demonstrates the symptom acuity between group A=early mobilization and group B=late mobilization group.

DISCUSSION

This is the first study to directly compare the effects of joint mobilization treatment timing to changes in ROM and self-reported functional outcomes. Anecdotal evidence based upon the Physical Stress Theory[18] suggests that if one actively uses a newly gained ROM after mobilization, that patient would maintain greater gains than those who did not continue to stress the newly lengthened tissues. Considering this evidence, we hypothesized that individuals receiving joint mobilization early in the treatment session would demonstrate better long-term ROM improvements as compared to individuals who received the same treatment at the end of their session.

The present study results demonstrate an early trend toward contradicting our hypothesis since there were no statistically significant changes between groups in regard to ROM at the 1-week and 4-week follow-up. There were also no statistically significant changes between groups in regard to self-reported functional status (FOTO) at the 1-week and 4-week follow-up.

However, there appeared to be an early trend towards significance for the late mobilization group in regard to ROM. This trend can potentially be explained by the amount of warm-up time. In this study, we used a 10-minute warm-up as the standard. To our knowledge, there is no current evidence looking at warm-up time and its effect on joint mobilization, which presents an idea for future research. Those individuals in the late mobilization group may have received more adequate tissue warm-up prior to the joint mobilizations. The increased tissue extensibility allowed for greater ROM gains both during and between sessions, which would potentially explain the trend that was found. The late mobilization group was able to complete a 10-minute warm-up, followed by a full therapeutic exercise regimen.

The difference in warm-up time may also help explain the change in functional outcome that was observed. Those individuals in the late mobilization group had a trend toward greater gains in ROM directly at the end of the session, leading to an overall greater perceived functional improvement immediately following each session. This trend will be explained in more detail later in this discussion. Future researchers should consider using a longer length of warm-up. An active warm-up of 10 to 15 minutes may be most appropriate to improve tissue extensibility.[35]

As previously mentioned, another trend that the findings of our current study

Table 4. Mann-Whitney U Data

Active flexion	U1	U2
IE A vs B	9	7
IE vs Pre mobs	12.5	15.5
Pre vs Post 1st time; A	9	12
Pre vs Post 1st time; B	2	14
Pre vs Post 2nd time, A	7	9
Pre vs Post 2nd time, B	6	10
IE vs final	5.5	10.5
Active Abduction		
	U1	U2
IE A vs B	21	15
IE vs Pre mobs	21	15
Pre vs Post 1st time; A	20.5	15.5
Pre vs Post 1st time; B	21.5	14.5
Pre vs Post 2nd time, A	18.5	17.5
Pre vs Post 2nd time, B	19.5	16.5
IE vs final	8	8
Passive Flexion		
	U1	U2
IE A vs B	12.5	7.5
IE vs Pre mobs	8	8
Pre vs Post 1st time; A	5.5	10.5
Pre vs Post 1st time; B	5	11
Pre vs Post 2nd time, A	6.5	9.5
Pre vs Post 2nd time, B	4.5	11.5
IE vs final	5	11
Passive Abduction		
	U1	U2
IE A vs B	8	8
IE vs Pre mobs	5	11
Pre vs Post 1st time; A	5.5	10.5
Pre vs Post 1st time; B	5	11
Pre vs Post 2nd time, A	7	9
Pre vs Post 2nd time, B	6.5	9.5
IE vs final	6	10
Passive ER		
	U1	U2
IE A vs B	11	5
IE vs Pre mobs	7	9
Pre vs Post 1st time; A	7.5	8.5
Pre vs Post 1st time; B	13	3
Pre vs Post 2nd time, A	5.5	10.5
Pre vs Post 2nd time, B	6	10
IE vs final	2	14

Above are the U values found between the varying groups. IE means initial evaluation, ER means external rotation, A means early mobilization group, and B means late mobilization group. All values had a critical value of 1 to achieve statistical significance.

revealed is that late mobilization has a greater impact on self-reported functional outcome (FOTO) gains compared to early mobilization at a 4-week follow-up (increase of 23, increase of 14, respectively). The mean difference between groups demonstrated a 9-point improvement in the later mobilization group over the early mobilization group. While the between group differences did not reach statistical significance, the very small sample size of this pilot study results in a critical value that is extremely challenging to attain in the comparison of two clinically accepted interventions. The underlying challenge for future studies is to determine whether or not this seemingly large numerical change is larger than that of the overall population resulting in a clinically significant difference, or if the change is actually smaller, resulting in no significant difference.

Due to variability of subject-specific impairments, it was decided that there would not be specific joint mobilizations that each participant was to receive. This decision was made due to current practice standard, as each patient is evaluated individually. Data collectors were instructed to provide intervention to each patient based upon that patient's specific impairments. There are both pros and cons to this decision. First, the fact that no standardization was given in regard to mobilization technique could be considered a positive as it allowed for each subject to receive the mobilization procedures specific to his or her needs, theoretically allowing for the most improvement possible. In turn, the result would have provided more generalizability to other patients with shoulder pain.

At the same time, the decision to use non-standardized mobilization techniques may have prevented us from finding a statistically significant effect. Some subjects may have received only glenohumeral mobilization, some may have only received thoracic mobilization, and some may have received a combination. Therefore, our results may have been different depending on which mobilization techniques were being used. Tate et al[2] performed a case series where they standardized which specific joints should be targeted when performing joint mobilizations. In a systematic review, 6 studies that met the inclusion criteria combined joint mobilizations with therapeutic exercises. All of the studies but one did not have a standardization of joint mobilizations; they were simply applied to the glenohumeral joint.[3] A majority of the studies looking at efficiency

Table 5. Range of Motion Data

		IE	1 week pre-mobilization	1 week post-mobilization	4 week pre-mobilization	4 week post-mobilization
Active Flexion	Group A	138.5°	150°	165°	156.5°	150°
	Group B	135°	152.5°	159°	155°	156.5°
Active Abduction	Group A	107.5°	122.5°	140°	142.5°	147.5°
	Group B	132.5°	145°	153.5°	160°	168.5°
Active IR†	Group A	N/A	0.5	0.5	2	1
	Group B	N/A	-0.5	0	0.5	1.5
Active ER†	Group A	N/A	0.5	0	0	0
	Group B	N/A	-0.5	0	0	0.5
Passive Flexion	Group A	150°	167.5°	172.5°	165°	167.5°
	Group B	140°	160°	165°	156.5°	162.5°
Passive Abduction	Group A	137.5°	150°	167.5°	165°	170°
	Group B	160°	147°	156°	165°°	170.5°
Passive ER	Group A	80°	90°	90°	75°	77.5°
	Group B	60°	75°	81°	86.5°	89°

The above table provides the median range of motion in degrees or spinal segment level (†) change. Group A is the early mobilization group. Group B is the late mobilization group.
Abbreviations: IE, initial evaluation; IR, internal rotation; ER, external rotation.

of joint mobilizations in adhesive capsulitis had varying protocols, with no specific joint mobilizations.[4] In the end, the majority of the research literature has looked at the effect that mobilizations play on the glenohumeral joint only. Therefore, that is why we suggest choosing specific joints that mobilizations should be applied to during this study.

Another possibility for the lack of statistically significant findings is the time of follow-up. The length of follow-up was 1 week and 4 weeks from the initial evaluation. It is possible that the 4-week follow-up time frame was too short to show significance within or between groups. In this case, a question of concern is brought forth, as to whether a 12-week (3-month) follow-up should be added, or discharge from skilled physical therapy be considered as a more appropriate final follow-up. It should be considered that even though a 4-week follow-up was chosen, this time frame may not have been significant enough to show a true change in ROM or self-reported functional outcome. By extending the length of the follow-up or until the patient is discharged from care, investigators may have greater ability to discover the possibility of statistical significance. Therefore, we are recommending that future researchers heavily consider a longer follow-up time frame.

A total of 10 clinicians volunteered to collect data for the study over a 6-month time frame. However, only 6 of the volunteers were able to either collect data for the study or exclude subjects. For future studies, the length of the data collection period should be increased to allow for the possibility of a larger sample size. Secondary to investigators finding a 40% change in median functional scores between the two groups, it is recommended that future investigators use a sample size of 32 subjects to show adequate power and statistical significance ($\alpha = 0.05$, $\beta = 0.8$, SD = 1.4). For this pilot study, a total of 8 subjects were included over a 6-month time frame. As a result, the total length of future studies may need to be 24 months to recruit the proper number of subjects. Also, improving the incentives for data collectors or subjects (as there were none) may be considered, thus generating more interest.

Considering our exclusion criterion and its effect on the elimination of subjects, a total of 8 subjects were eliminated secondary to acute shoulder surgery. For future studies, researchers should consider including joint mobilizations for individuals recently undergoing shoulder surgery between 6 to 12 weeks postoperatively. The main concern while performing joint mobilizations following a surgical intervention is disrupting the surgical procedure/fixation. According to Muraki et al,[36] glenohumeral distraction, anterior translation, and posterior translation glides had no significant alteration onto the stresses placed on a repaired supraspinatus tendon. However, clinicians need to take into account the specific patient postoperative guidelines and continue to adhere to the limitations set forth by those postoperative guidelines. Thus, inclusion of appropriate patients who underwent a surgical procedure would likely increase the number of subjects included in future studies.

However, researchers would need to consider a multitude of factors before including postsurgical subjects in the study. As previously mentioned, patient-specific postoperative guidelines need to be considered to ensure that joint mobilizations are safe at the selected time frame in the rehabilitative process. Furthermore, it may be difficult to truly assess the change joint mobilizations had on ROM or function following a surgical procedure. It is the authors' opinion based off of clinical experience that ROM and functional gains are more of a result of acute tissue healing than timing of interventions within a single treatment session as patients progressed through postoperative rehabilitation. Because of this, it may be difficult to determine what gains were made secondary to joint mobilizations versus tissue healing following surgery.

A total of 8 subjects were excluded from the study secondary to not having a 20° ROM difference side-to-side. Tate et al[2] demonstrated that a total difference of 10° is adequate enough to demonstrate a ROM difference from side-to-side. For the purpose of this study, we attempted to capture individuals with larger ROM differences to demonstrate a significant change in ROM. However, future researchers should consider changing inclusion criteria from a 20° ROM difference to a 10° ROM difference to capture more individuals for the study that would benefit from joint mobilizations.

When comparing acuity of symptoms, co-morbidities, fear, and BMI between groups, the late mobilization group appeared to have symptoms of a longer duration, relatively the same amount of co-morbidities as the early mobilization group, lower fear-avoidance scores, and lower BMI scores compared to the early mobilization group. The median range of symptoms for the early mobilization group was 15 to 52 days compared to 56.5 to 135 days for the late mobilization group. Because there were no statistical differences between groups, acuity of symptoms may not have played a role related to ROM changes. However, the trend towards greater functional outcomes with the late mobilization group compared to the early mobilization may be related to chronicity of symptoms. It is the authors' opinion that individuals with a longer duration of symptoms may have reported greater increases in function secondary to returning to activities they have been unable to participate in for a longer period of time. This factor may have contributed to patients perceived levels of improvement, regardless of tissue histological factors.

When analyzing the effect fear has on individuals and their functional outcomes, Leeuw et al[37] demonstrated when fear of pain and other psychological factors are not perseverated on by patients, clinicians should expect a normal recovery. However, when elevated fear levels are present, avoidance behaviors may occur, which could result in decreased functional levels secondary to pain.[37] Because of this, the lower fear avoidance scores of the late mobilization group may have contributed to increased levels of function as demonstrated on FOTO.

According to the World Health Organization Body Mass Index classification, individuals from the late mobilization group were classified as overweight whereas the early mobilization group was classified as morbidly obese. It should be noted though that one individual from each group chose not to disclose information needed to calculate their BMI. However, Racette el al[38] has discussed that obesity is related to a decreased aerobic capacity that also is likely to decrease function in patients. Although our subjects were randomly assigned to groups, the differences in obesity classification between groups may have contributed to the greater functional outcomes for the late mobilization group.

LIMITATIONS

There are several limitations to this study. First, as this was a pilot study, the sample size was intentionally small (8 subjects). All subjects were older than the average age of the general population of patients presenting to physical therapy for orthopaedic diagnoses in the same health system. As such, the generalizability of the findings may be questioned.

Second, a large exclusion criterion had a significant effect on reducing the size of the sample. A total of 23 subjects were eliminated from the study prior to initial measurements for having met at least one of the exclusion criteria. Third, the joint mobilization techniques used in this study were not standardized. However, despite the amount of evidence regarding joint mobilizations for improving function, there are no standard recommendations regarding which specific type of mobilization should be used. Because of this, individuals received mobilizations based upon clinician judgment to improve current impairments. Fourth, the subjects included in this study were selected based upon a sample of convenience.

Based on the size and exclusivity of the sample, and the limited conclusions regarding timing of joint mobilization and its effect on ROM and self-reported function, further investigation of the methods is required using larger and more diverse populations.

CONCLUSION

This pilot study did not demonstrate that timing of mobilization has a statistically significant difference in the improvement of active or passive ROM. However, the group of subjects who received mobilizations at the end of their treatment session did demonstrate a trend towards improved self-reported functional status compared to those who received mobilizations early in their treatment session. Future studies should consider including a greater number of subjects, involving subjects that have a ROM difference of 10° compared to 20°, and limit joint mobilizations only to the glenohumeral joint in order to determine if there is a difference in mobility and function based upon intra-session timing of mobilizations. In addition, consideration should be given to the limitations that existed within this study, attempting to minimize them in order for the findings to be applicable to the general population across the lifespan.

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