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Original article

# One-week time course of the effects of Mulligan's Mobilisation with Movement and taping in painful shoulders

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ABSTRACT

Previous research suggests that Mulligan's Mobilisation-with-Movement (MWM) technique for the shoulder produces an immediate improvement in movement and pain. The aims of this study were to investigate the time course of the effects of a single MWM technique and to ascertain the effects of adding tape following MWM in people with shoulder pain. Twenty-five participants (15 males, 10 females), who responded positively to an initial application of MWM, were randomly assigned to MWM or MWM-with-Tape. Range of movement (ROM), pressure pain threshold (PPT) and current pain severity (PVAS) were measured pre- and post-intervention, 30-min, 24-h and one week follow-up. Following a one-week washout period, participants were crossed over to receive a single session of the opposite intervention with follow-up measures repeated. ROM significantly improved with MWM-with-Tape and was sustained over one week follow-up ($p < 0.001$; 18.8°, 95% confidence intervals (CI) 7.3–30.4), and in PVAS up to 30-min follow-up (38.4 mm, 95% CI 20.6–56.1 mm). MWM demonstrated an improvement in ROM (11.8°, 95% CI 1.9–21.7) and PVAS (40.4 mm, 95% CI 27.8–53.0 mm), but only up to 30-min follow-up. There was no significant improvement in PPT for either intervention at any time point. MWM-with-Tape significantly improved ROM over the one-week follow-up compared to MWM alone (15.9°, 95% CI 7.4–24.4). Both MWM and MWM-with-Tape provide a short-lasting improvement in pain and ROM, and MWM-with-Tape also provides a sustained improvement in ROM to one-week follow-up, which is superior to MWM alone.



## 1. Background

Shoulder pain with concomitant limitation of movement is a common problem, with a prevalence of approximately 20–33% in the general population (van der Windt et al., 1995; Vermeulen et al., 2006; McBeth and Jones, 2007) and as high as 46% in some sports (Kibler and Safran, 2005). Physiotherapy treatment is often the first choice of management of shoulder symptoms (van der Windt et al., 1995) and manual therapy techniques are commonly used to treat shoulder pain and functional limitations such as restricted range of movement (ROM).

Mobilisation with Movement (MWM) is a manual therapy technique that is gaining popularity for the management of musculoskeletal pain. It involves the application of a sustained glide to a painful or stiff joint by the therapist while the patient performs a concurrent active movement of the joint (Mulligan, 2003, 2004; Vicenzino et al., 2011). One preliminary study has demonstrated immediate effectiveness in the use of MWM techniques on shoulder pain with limited ROM by improving ROM and pressure pain threshold (PPT), when compared to sham and no treatment (Teys et al., 2008). Specifically, this study used a posterolateral glide of the humeral head while the patient actively raised their arm in the plane of the scapula to the point of pain onset.

Mulligan proposes that MWM is clinically useful if a single application demonstrates a measureable improvement in joint range of movement and pain (Mulligan, 2004), although there is very little evidence to demonstrate effects of MWM beyond the immediate time frame of a single treatment session. Furthermore, Mulligan also advocates the use of taping as an adjunct to the MWM technique, suggesting it may prolong the benefits of MWM

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(Mulligan, 2004). There is some low level evidence to support the use of taping in conjunction with MWM in improving pain and function in musculoskeletal conditions such as acute ankle inversion injury (O'Brien and Vicenzino, 1998), however the sustained effects of the MWM and the additional effects of taping in people with non-specific shoulder pain have not been investigated. The aim of this study was to assess the time course of the effects of one treatment session of MWM on participants with non-specific shoulder pain, who responded positively to an initial application of a glenohumeral MWM, and to investigate the effects of adding tape to the MWM technique.

## 2. Methods

A repeated-measures, crossover, randomised trial was conducted to evaluate the time-course effects of a shoulder MWM and taping on ROM, pain severity and PPT. This design was used to reduce the effects of individual variation and strengthen internal validity.

### 2.1. Participants

Twenty-five participants (Table 1) were recruited from the general community in southeast Queensland, Australia. Participants were included in the study if they were aged over 18 years, had reported pain in the antero-superior aspect of one shoulder, duration of the shoulder condition for longer than 4 weeks, reduced shoulder elevation due to pain, and who responded positively to the application of the shoulder MWM at the initial screening. A positive response to the MWM was defined as a greater than 10° improvement in pain-free ROM shoulder elevation in the plane of the scapula (Teys et al., 2008; Chen et al., 2009).

Volunteers were excluded from the study if they had a history of cancer, previous fractures of the shoulder complex, recent shoulder surgery or corticosteroid injection, any neurological or autoimmune disorder or any recent shoulder dislocation. In addition, volunteers were excluded if they had a known allergy to adhesive tape, or if their shoulder pain was exacerbated on neck examination by an experienced musculoskeletal physiotherapist (Donatelli, 2012). An experienced physiotherapist with post-graduate physiotherapy qualifications and training in Mulligan's techniques performed all screenings and interventions. Ethical clearance was obtained from the Institution's Human Research Ethics Committee and all participants signed informed consent prior to enrolment in the study.

**Table 1**
Baseline participant characteristics ($N = 25$). Values are means (standard deviation) unless otherwise stated.

| Characteristics | |
|---|---|
| Number of men (%) | 15 (60) |
| Age years | 45.4 (14.8) |
| Number (%) right side dominant | 24 (96) |
| Number (%) right side affected | 16 (64) |
| Employment status (%)[a] | |
| Not working | 2 (8) |
| Non-manual | 14 (56) |
| Manual | 9 (36) |
| Duration of condition months | 7.7 (7.2) |
| Current pain[b] | 49 (25) |
| Range of shoulder elevation degrees | 97 (19) |
| Pressure pain threshold kPa | 334 (148) |

[a] Not working = unemployed or home maker; Non-manual = office, clerical or other desk work; Manual = physical work.
[b] 100 mm visual analogue scale; 0 mm = no pain, 100 mm = worst pain.

### 2.2. Outcome measures

The outcome measures were range of shoulder ROM, PPT and pain severity, which were taken by an investigator skilled in their application. Outcome measures were taken at baseline, immediately post-intervention, and at 30-min, 24-h and 7-days post-intervention.

#### 2.2.1. Range of movement

A universal goniometer was used to measure the participant's pain-free shoulder abduction ROM in the plane of the scapula. The universal goniometer has been shown to have good intra-rater reliability if consistent landmarks are used (Hayes et al., 2001; Mullaney et al., 2010). Measurement was standardised by aligning the centre of the goniometer with the centre of axis of the shoulder joint posteriorly; one arm of the goniometer aligned with the lateral border of the scapula and the other arm aligned with the humerus (Teys et al., 2008). These points were marked with a permanent marker. To ensure arm elevation was in the plane of the scapula, one arm of the goniometer was placed along the superior border of the scapula with the other arm of the goniometer moved forward 30° from the coronal plane. A vertical line was marked on the wall to align with this. The participant was then asked to elevate their arm following the vertical line on the wall, with the thumb pointed upward for standardisation. Three measures were recorded and the average calculated for further data analyses.

#### 2.2.2. Pain severity

Participants were asked to rate the severity of their current pain using a 0–100 mm visual analogue scale (current pain severity (PVAS); 0 = no pain at all, 100 = worst pain experienced). This has been validated as a reliable measure of pain severity (Gallagher et al., 2001).

#### 2.2.3. Pressure pain threshold (PPT)

Pressure pain threshold was measured over the point that was most painful to manual palpation of the antero-superior aspect of the affected shoulder. A digital pressure algometer (Somedic AB, Farsta, Sweden) was used to measure the pressure applied to the site via a rubber tipped probe (1 $cm^2$) held perpendicular to the skin. The pressure was applied at a rate of 40 kPa/s and the participant was asked to press a button immediately at the first onset of pain. Three measures were recorded and the average calculated for further data analyses. Pressure algometry has shown good inter-rater and intra-rater reliability and correlation with other measures of pain across all age groups (Walton et al., 2011).

### 2.3. Intervention

All participants were randomised to receive a single intervention session consisting of three sets of 10 repetitions of MWM or MWM-with-Tape. All participants then underwent one week of follow-up outcome assessment, followed by a one-week washout period. After the washout period, all participants received the opposite intervention (i.e., a single session of MWM or MWM-with-Tape) and follow-up assessments for one week following the second intervention.

A physiotherapist blinded to the measures applied the shoulder MWM. The MWM procedure was explained to the participant prior to its application, including the explanation that it must be pain-free and that the MWM would cease immediately if any pain was experienced during the application (Mulligan, 2003; Hing et al., 2008; Teys et al., 2008). The participant was seated with an erect posture and feet flat on the floor. The therapist stood on the

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opposite side to the affected shoulder and applied the technique as described by Mulligan (2004). With one hand over the spine of the scapula posteriorly and the thenar eminence of the other hand placed over the anterior aspect of the head of the humerus, the therapist applied a postero-lateral glide to the humeral head of the affected shoulder, which was sustained while the participant raised their arm along the plane of the scapula without pain or discomfort as far as they could go or to the point of pain onset. Participants randomised to the MWM-with-Tape intervention then received tape applied to the affected shoulder. The skin was first wiped with alcohol and a single piece of porous hypoallergenic adhesive tape (Fixomull; Smith and Nephew, Brisbane, Australia) approximately 400–600 mm long and 50 mm wide, was applied to the shoulder. The participant was seated in an upright position and the tape was laid on the skin starting at the anterior shoulder and running over the acromion and diagonally down over the scapula to a point approximately level with T7 spinal segment. The treating therapist aimed to manually position the humeral head relative to the acromion as for the MWM manual technique while rigid sports tape (Leukosports, Beiersdorf AG, Germany) was applied overlying the Fixomull (Fig. 1). All participants were given an education pamphlet regarding management of possible adverse reactions to tape along with instructions on how to remove the tape after 48 h post-application or earlier if they experienced any discomfort or adverse reaction.

**Fig. 1.** Lateral and posterior views of the taping technique used in the MWM-with-Tape intervention.

## 3. Data analysis

The two independent variables in this study were Intervention (MWM, MWM-with-Tape) and Time (baseline, immediately post-intervention, 30-min, 24-h, and 7-days post-intervention). Data was entered into an electronic spreadsheet and intention-to-treat analyses were carried out using the Statistical Package for Social Sciences (SPSS V19.0, IBM Inc. Chicago, USA). Repeated-measures analyses of variance (ANOVA) with within-subjects factors of Time, Order (of interventions), and a between-subjects factor of Intervention, with Bonferroni correction, were used. *Post hoc* testing was conducted on significant interaction or main effects ($p < 0.05$). A sample size of 18 was required based on 80% power to detect a mean difference of 11.7° (standard deviation 11.9, alpha = 0.05) in ROM between interventions (Teys et al., 2008). The sample was increased to 22 to allow for 20% drop out.

## 4. Results

Twenty-five participants were recruited between February 2006 and February 2009 (Table 1). There were two participants lost to follow-up, one from each intervention (Fig. 2). The first participant dropped out after the first week due to the distance required to travel for assessments, and the other withdrew after day one for personal reasons. All participants received the intervention as allocated and there were no adverse events reported from either intervention. There was no significant difference for any outcome measure after the one-week washout period, suggesting that the washout period was effective. In addition, there was no order effect for any of the outcome measures, suggesting that the effects of the intervention were not influenced by whether the participant received, for example, tape during the first intervention session or the second (Fig. 3).

There was a significant intervention ($p = 0.001$) and time effect ($p < 0.001$) for ROM, as well as a significant time × intervention interaction ($p = 0.03$). *Post hoc* testing revealed the MWM-with-Tape intervention was superior to the MWM intervention in improving ROM immediately post-intervention, at 24-h and one-week follow-up (Table 2). In addition, the MWM-with-Tape intervention showed significant improvement at all follow-up time points compared to baseline (Table 2). The only significant improvement in ROM from baseline for the MWM intervention, was immediately post-intervention ($p < 0.001$) and at 30-min follow-up ($p = 0.016$), but not beyond (Table 2).

There were no significant differences over time within interventions ($p = 0.7$) or between interventions ($p = 0.2$) for PPT.

Pain severity (PVAS) was significantly different over time ($p < 0.001$) but not between groups ($p = 0.7$). PVAS significantly improved in both the MWM and MWM-with-Tape interventions from baseline to immediately post-intervention (mean improvement 36.5 mm, 95% confidence interval (CI) 23.5–49.6, $p < 0.001$; and 35.6 mm, 95% CI 24.4–46.7, $p < 0.001$ respectively) and to 30-min post-intervention (mean improvement 40.4 mm, 95% CI 27.8–53.0, $p < 0.001$; and 38.4 mm, 95% CI 26.6–50.1, $p < 0.001$ respectively), but not beyond (Table 2).

## 5. Discussion

This is the first study to follow the short-term time course of response to a single intervention of MWM with and without tape, in people who demonstrated an initial positive response to a MWM.

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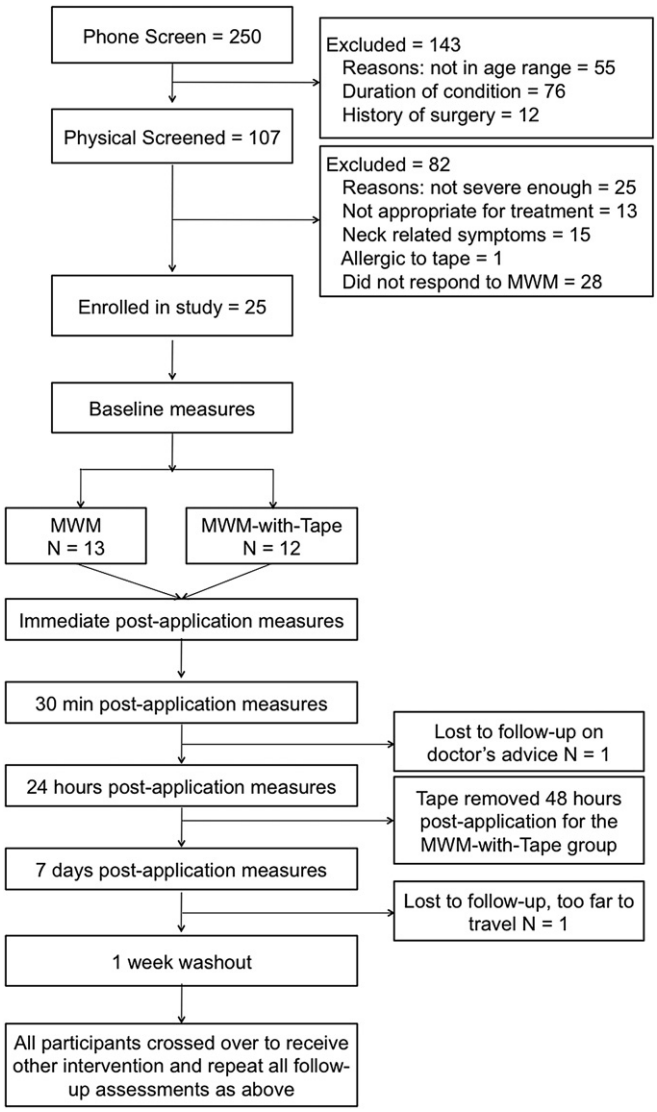


**Fig. 2.** Flow chart time course of treatment and measures.

**Table 2**
Means (standard deviations) of the MWM with tape and MWM groups at baseline and follow-up outcome measures, and between-intervention mean differences (95% confidence intervals).

| | MWM-with-Tape | MWM | MWM-with-Tape versus MWM[a] |
|---|---|---|---|
| *ROM (degrees)* | | | |
| Baseline | 99.4 (24.1) | 102.6 (22.7) | −3.5 (−15.1 to 8.1) |
| Post-intervention | 126.2 (22.7)[b] | 118.8 (20.5)[b] | 7.5 (1.2 to 13.8)* |
| 30-min | 120.6 (26.4)[b] | 114.5 (26.2)[b] | 6.0 (−1.1 to 13.1) |
| 24-h | 120.1 (26.1)[b] | 105.9 (23.2) | 13.9 (3.0 to 24.8)* |
| 7-days | 118.3 (29.5)[b] | 101.7 (31.4) | 15.9 (7.4 to 24.4)* |
| *PPT (kPa)* | | | |
| Baseline | 335 (151) | 340 (142) | −5 (−49 to 37) |
| Post-intervention | 345 (170) | 344 (139) | 1 (−46 to 47) |
| 30-min | 358 (183) | 341 (144) | 18 (−40 to 75) |
| 24-h | 313 (158) | 267 (109) | 46 (−18 to 109) |
| 7-days | 321 (181) | 325 (140) | −4 (−56 to 48) |
| *PVAS* | | | |
| Baseline | 42.9 (25.7) | 45.5 (26.8) | 2.6 (−7.7 to 12.9) |
| Post-intervention | 7.6 (11.0)[b] | 8.6 (10.9)[b] | 1.0 (−4.9 to 6.9) |
| 30-min | 4.7 (8.4)[b] | 4.5 (6.8)[b] | −0.2 (−4.7 to 4.3) |
| 24-h | 35.1 (22.1) | 33.4 (27.9) | −1.7 (−12.1 to 8.7) |
| 7-days | 41.5 (32.3) | 35.7 (26.8) | −5.7 (−20.1 to 8.6) |

ROM: range of movement; PPT: pressure pain threshold; PVAS: current pain.
* $p < 0.05$.
[a] Positive score favours the MWM-with-Tape intervention.
[b] Significant difference from baseline ($p < 0.05$).

We observed that an application of the shoulder Mobilisation with Movement in conjunction with tape provided a statistically significant, and clinically meaningful (Mullaney et al., 2010), improvement of approximately 20° in ROM that was maintained for one-week in people with shoulder pain. In contrast, the application of the MWM alone produced improvement in ROM only up to 30 min post-intervention.

These results provide evidence to support the clinical notion that tape augments the beneficial effects of MWM in musculoskeletal shoulder pain (Mulligan, 2004). The addition of tape to an MWM appears to preferentially improve ROM rather than pain, as improvement in ROM was significantly greater in the MWM-with-Tape group at one-week follow-up, with no differences between groups for pain outcomes (PVAS or PPT) at any time point. Our findings of improvement in ROM with tape are consistent with other studies that have investigated the effects of tape on other musculoskeletal conditions. A single application of tape similar to the one used in this study was found to significantly increase

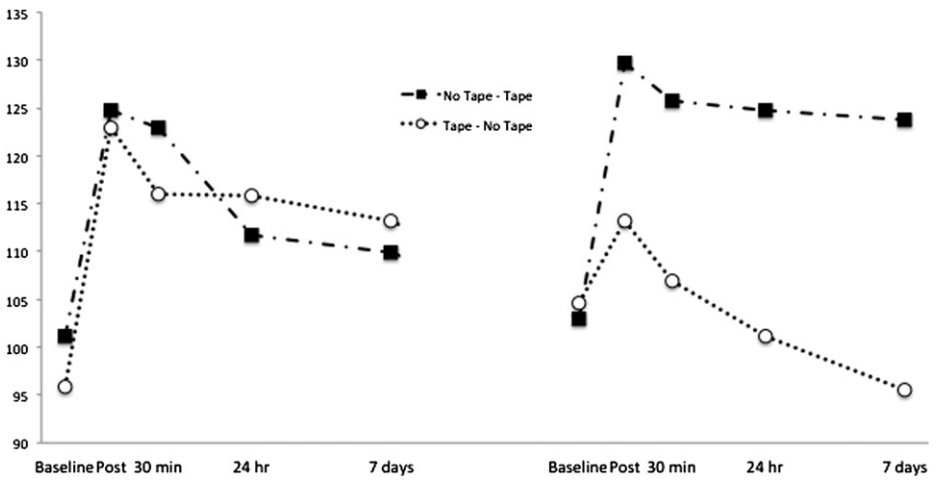


**Fig. 3.** Mean values for the MWM-with-Tape and MWM groups with crossover after one week washout.

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external rotation shoulder ROM in elite junior tennis players (McConnell and McIntosh, 2009). Tape has also been shown to enhance ankle ROM (O'Brien and Vicenzino, 1998), increase and maintain arch height after 10 min of walking (Franettovich et al., 2010), and maintain arch height during a jump-drop landing task (Cordova et al., 2010).

In contrast to ROM, improvements in current pain severity were not maintained beyond 30-min follow-up for either intervention. There is conflicting evidence around the effect of taping on pain. One previous study reported no significant difference in PPT between a tape and sham tape condition in people with tennis elbow (Vicenzino et al., 2003), whereas other studies have demonstrated a significant reduction in pain following the application of tape in conditions such as patellofemoral pain syndrome, shoulder pain and plantar fasciitis (Wang, 1999; Radford et al., 2006; Lan et al., 2010). Due to conflicting evidence regarding the contribution of tape to reducing pain, the mechanism underlying tape in shoulder conditions warrants further investigation.

The mechanisms underlying MWM or tape are unclear, but are likely to be multi-factorial. Under both static and dynamic conditions, taping has been shown to change biomechanical parameters at other body parts, such as increased vertical navicular and medial longitudinal arch heights, reduced tibial internal rotation and calcaneal eversion, as well as alter foot plantar pressure patterns (Vicenzino et al., 2005; Radford et al., 2006; Vicenzino et al., 2007; Franettovich et al., 2008, 2010). MWM may also produce a biomechanical change, evidenced by a cadaveric study that showed a technique replicating the glenohumeral MWM produced a 7.7 mm posterior displacement of the humeral head during shoulder abduction (Bradley et al., 2009).

An alternative mechanism of effect for MWM may be neurophysiological, as MWM produces rapid hypoalgesia and sympathoexcitation, greater than effects seen with placebo or control conditions (Vicenzino et al., 1996; Paungmali et al., 2003a). One explanatory mechanism underlying this manipulative therapy-induced pain modulation is the activation of the descending pain inhibitory system within the central nervous system, initiated by stimulation of the lateral-dorsal periaqueductal gray (Vicenzino et al., 1998; Sterling et al., 2001; Paungmali et al., 2003b). To our knowledge, no studies have investigated the mechanisms underpinning the clinical effects of tape or MWM in the shoulder.

This is the first study to investigate the one-week time course of response to a single treatment of MWM with and without tape. There is a dearth of comparable research on the time course of effects of other manual therapy techniques. In people with low back pain, a single session of the Mulligan MWM (bent-leg-raise technique) has previously demonstrated improvement in straight leg raise ROM and pain severity immediately post-intervention, that was sustained for 24-h (Hall et al., 2006). Similarly, a single lower cervical manipulation has previously demonstrated significant amelioration of lateral flexion ROM asymmetry in the cervical spine at 30-min and at 4-h follow-up in people with a history of neck trauma, with improvements sustained up to 48 h follow-up in people with no history of neck trauma (Nansel et al., 1990). While our study demonstrated a single session of MWM-with-Tape has a sustained effect (up to one week) on improvement in ROM, it would be interesting to investigate the additive effects of repeated treatment sessions over time on outcomes in shoulder pain.

Comment is warranted on the fact that our study investigated the effects of a single treatment session of MWM with and without tape. This is not representative of standard physiotherapy practice, which commonly involves more than one treatment session and a multimodal approach (Ginn et al., 1997). Given the positive effects of a single intervention of MWM-with-Tape as identified in our study, there is a need to investigate the short- and long-term effects of a multimodal treatment of MWM-with-Tape and exercise in people with musculoskeletal shoulder pain.

It must also be noted that the participant population used in this study were likely to have been heterogeneous in terms of diagnostic category, as the primary inclusion criteria was pain that limited shoulder range of movement, which may be associated with a variety of shoulder conditions. This is not necessarily a limitation of the study, as two systematic reviews, which summarised approximately 50 diagnostic tests for shoulder conditions, have shown that there are very few tests of diagnostic value to clinicians (Hegedus et al., 2008; Snyder, 2009). Thus, heterogeneity in our sample population might improve the translation of findings to a broad patient population in normal physiotherapy practice. However, another primary inclusion criterion for the sample in this study was that participants should have an immediate positive response to MWM during the screening procedure. This limits the translation of the findings to the general patient population.

Another limitation of this study is the absence of blinding of both the outcome assessor and study participants to the interventions. While best efforts were made to ensure the outcome assessor remained impartial during the assessments, the risk of bias should be considered when interpreting the findings of this study.

For people with shoulder pain who have demonstrated a positive response to an initial MWM, MWM-with-Tape provides a sustained improvement in ROM, but not pain, to one-week follow-up, which is superior to MWM alone.

## 6. Conclusion

In people with shoulder pain who demonstrated a positive response to an initial MWM, a single intervention of MWM-with-Tape provided an improvement in ROM for up to one week, compared to MWM alone. This current study adds to the growing body of evidence demonstrating positive sustained effects of MWM in combination with tape, and may help direct treatment planning for patients with musculoskeletal shoulder complaints.

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