The Egyptian Journal of Hospital Medicine (October 2021) Vol. 85 (1), Page 3043-3053

Effect of Mulligan Technique on Subacromial Impingement Syndrome: A Systematic Review

Mohamed Abdellatif Hassan[1*], Enas Fawzy Elanni[2], Karima Abdelaty Hassan[2], Karim Ghuiba[2]

[1] Department of Physiotherapy, Misr International Hospital, Giza, Egypt

[2] Department of Physical Therapy for Musculoskeletal Disorders and Its Surgery, Faculty of Physical Therapy, Cairo University, Egypt.

***Corresponding author:** Mohamed Abdellatif Hassan, **Mobile:** (+20) 01111028319, **E-Mail:** elmezaien@yahoo.com

ABSTRACT

Background: Subacromial impingement syndrome (SIS) is considered the most prevailing cause of shoulder pain. Although Mulligan's technique may be useful in treating shoulder impingement, its significance in areas of range of movement (ROM), pain, and function is still debated.

Objective: To systematically review and summarize the best evidence on treating subacromial impingement syndrome using mobilization with movement.

Patients and Methods: Databases Cochrane Library Web search, PEDro and PubMed were searched for RCTs published in English language from inception to September 2019, updated later to 7th of July 2021. Reference lists of relevant publications were also screened. Two reviewers separately identified relevant papers based on the inclusion criteria. The identified papers by both authors were obtained in full text. To evaluate methodological quality and risk of bias, the Cochrane risk of bias tool was used. We used the random-effects model in all analyses for meta-analyses.

Results: A total of 11 RCTs with a total number of 358 adults with subacromial shoulder pain were included. They examined the effect of mobilization with movement (MWM) combined with exercise with or without taping against rotator cuff strengthening, ROM exercises, isometric strengthening, shoulder joint mobilization, and sham techniques. Meta-analysis was done comparing MWM against exercise and found a significant difference in VAS and a non-significant difference in SPADI.

Conclusion: Shoulder mobilization with movement combined with a supervised exercise program (ROM, and functional limitations) has a better impact on pain than exercise alone or sham in short-term with similar improvement to exercise in the long-term.

Keywords: Shoulder impingement, Mobilization with movement, Mulligan.

INTRODUCTION

Shoulder impingement contributes to 44–60% of all disorders causing shoulder pain, makes it the most familiar cause of shoulder pain [(1)]. Shoulder impingement syndrome can be caused by several factors include weakness of the rotator cuff muscles, morphology of the acromion, muscle imbalance, laxity or tightness of the joint capsule, dysfunctional glenohumeral and scapulothoracic kinematics, degeneration and the tendons or bursa inflammation[(2)]. Subacromial impingement is distinguished by painful shoulder, elevation or overhead activities of the arm aggravate pain in adults. It has a huge impact on socioeconomic status due to individual's working ability limitation[(3, 4)].

Various physical therapy interventions, which include thermotherapy, electrotherapy, therapeutic exercise therapy, and manual physical therapy are used to treat impingement of the shoulder [(5)]. Therapeutic exercises generally have a positive effect in restoring shoulder mobility and retraining muscle imbalance in SIS [(6, 7, 8)]. Exercise therapy was described by **Haik *et al.*** [(9)] as the first choice to improve function, range of movement and pain and range of motion in treatment of shoulder. The reduction of pain can be accelerated in the short-term by adding of mobilizations to exercises. Mobilization with movement (MWM) is a manual therapy technique used for musculoskeletal pain management. The therapist applies a sustained glide to a painful or stiff joint while the patient performs a concurrent active movement [(10)]. **Mulligan** [(10)] advocated that MWM is clinically useful when a single application exhibits a measurable pain and range of movement improvement in joint.

A recent systematic review **Stathopoulos *et al.*** studied the effect of mulligan's technique on peripheral joints, concluded that MOM for shoulder adhesive capsulitis and hip pain produced not only a statistically significant but also, a clinically significant ROM increase in all movement directions. On the contrary, a therapeutic benefit regarding ROM for shoulder impingement syndrome, shoulder dysfunction / pain, tight hamstring, knee arthritis, and chronic instability of the ankle could not be obviously settled [(11)].

The strength of evidence concerned with the clinical efficacy of Mulligan MOM is not clear. The purpose of this study was systematically reviewing the best evidence on the effectiveness of using Mulligan

Received: 23/5/2021
Accepted: 19/7 /2021

mobilization in patients with subacromial impingement to guide the development of standardized clinical guidelines. This could help directing clinical decision making by the physical therapists need to implement those applications or not.

MATERIALS AND METHODS

The review was cataloged on PROSPERO (PROSPERO 2020: CRD CRD42020162989) and executed according to PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-analyses) [12].

The electronic databases Cochrane Library Web search, PEDro (physiotherapy and evidence database) MEDLINE / PubMed were searched for RCTs published in English language from inception to September 2019, updated later until 7th of July 2021. Also, reference lists of relevant papers were checked.

Search strategy:

The following terms were used in the electronic databases for identifying articles: shoulder, glenohumeral, subacromial, rotator cuff, coracohumeral and internal. Moreover, mobilization with movement, Mulligan, posterolateral mobilization, inferior mobilization, hand behind back mobilization. Also, impingement*, tendinitis, tendinopathy and pain*.

Database search formulas are presented in (Appendix1). The criteria for inclusion and exclusion are shown in (Table 1).

Appendix (1): Search strategy and number of papers found in each database

Database	Number of citations	Keywords
PubMed	**Original 176** **Update 88**	Shoulder, glenohumeral, subacromial, rotator cuff, coracohumeral, internal, mobilization with movement, Mulligan, posterolateral mobilization, inferior mobilization, hand behind back mobilization, impingement* tendinitis, tendinopathy and pain*. Filters: Clinical trial Humans
Cochrane	**Original 106** **Update 55**	#1 shoulder #2 rotator cuff #3 coracohumeral #4 subacromial #5 internal #6 glenohumeral #7 #1 OR #2 OR #3 OR #4 OR #5 OR #6 #8 impingement* syndrome #9 tendinitis #10 tendinopathy #11 pain* #12 #8 OR #9 OR #10 OR #11 #13 #7 AND #12 #14 mobilization with movement #15 mulligan #16 posterolateral mobilization #17 inferior mobilization #18 hand behind back mobilization #19 #13 OR #14 OR #15 OR #16 OR #17 OR #18 #20 #13 AND #19
PEDro	**Original 346** **Update 28**	Mobilization with movement. Mulligan. Impingement

Table (1): Eligibility criteria of the included studies

Studies that were eligible for inclusion: • Published randomized controlled trials. • Trials that enrolled adult population (over 18 years old) clinically diagnosed with Subacromial impingement. • Either Acute, sub-acute or chronic. • Mobilization with Movement: Posterolateral mobilization. Inferior mobilization (hand behind back). • Studies that compared MWM to control, placebo, or standard care and studies that compared different doses, intensities, or timing of delivery of the same intervention were included.
Studies that were excluded: • Study designs other than randomized-controlled trials. • Review articles, surveys, case report, conference meetings, and case series. • Published abstracts with no full-text articles available. • Records in other languages than English, and abstracts not available. • Invasive interventions, surgery, or pharmacological therapy as the only treatment.

Selection Criteria:

Mendeley Desktop© (version 1.19.5) was used to pool titles and abstracts. Duplicates and irrelevant articles that didn't meet the inclusion criteria were removed using the software. Based on the eligibility criteria two reviewers (Mohamed Abdellatif (MA) and Karim Ghuiba (KG)) independently identified papers as relevant. Both reviewers matched their lists. Full text of papers identified by both authors were obtained. Any judgment disagreements were resolved by consensus. A third reviewer (Karima A. Hassan (KAH)) acted as arbiter. A flow chart of study selection is presented in **figure (1).**

Data extraction:

(MA and KAH) single-handedly extracted the suitable data and compared their findings to verify whether all suitable data were well extracted. They extracted author, year of publication, title, characteristics of participants, intervention/control, treatment duration, outcome measures, statistical tests used, results, and conclusions.

Assessment of risk of bias:

Three researchers (MA, KG, and KAH) unassisted evaluated the quality of selected articles by using the Cochrane risk-of-bias tool for randomized trials (RoB 2) Version 22 August 2019-assessment tool [(24)]. The structure of RoB 2 consisted of five main domains, emphasizing on different parts of trial design, conduct, and reporting. Each one of the domains contains a series of questions ('signaling questions') targeting information about the trial features that are relevant to the risk of bias. An algorithm is used for judgment about the risk of bias arising from each domain, according to answers to the signaling questions. Judgment could be 'Low' or 'High' risk of bias, or can express 'Some concerns'. These five main domains are: (1) bias due to defect in the randomization process, (2) bias caused by deviations from intended interventions, (3) bias because of missing outcome data, (4) bias in measurement of the outcome, (5) bias in selection of the reported result.

Statistical methods:

For comparative meta-analyses, review manager (RevMan – version 5.4.1) was used to analyze data acquired from included studies. We demonstrated pooled continuous effect measures as the mean difference (MD) with CI of 95%. I2 tests were used to express between-study statistical heterogeneity, which describes true variation across studies as a percentage, where values around 25% indicates low heterogeneity, 50% medium, and 75% high heterogeneity among studies. Random-effects model was implemented in all analyses [(13)]. Inter-rater agreement was calculated using Krippendorff's Alpha-Reliability (0.955). We couldn‘t assess Publication bias because of the scarcity of included studies.

RESULTS

Trial flow:

A total of 628 references resulted from database searching. When duplicates were removed, a total of 582 references were screened by title. Of these, 29 articles were screened by abstract, 27 met the inclusion criteria. After a full-text review, only 11 studies managed to meet the requirements of the review **(Figure 1)**.

Any disagreement during references screening process was settled by discussion. An update of the search has been conducted using the same keywords to the same databases until 7th July 2021. 171 references were found. Then duplicates were removed, 151 references were checked by title of these 6 articles screened by abstract, none met our eligibility criteria.

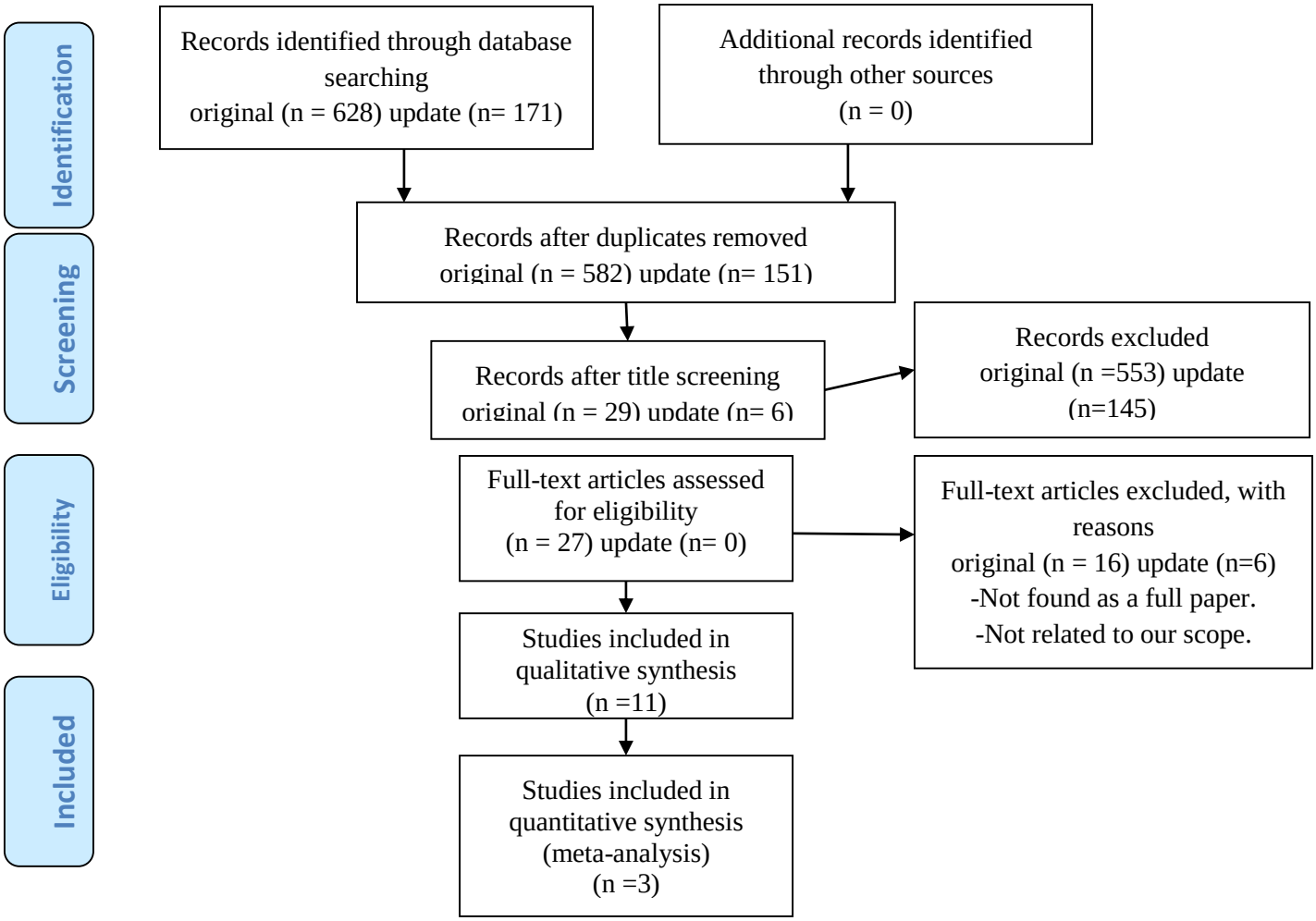

Figure (1): PRISMA flow chart.

Study characteristics:

Characteristics of the studies are shown in **(Table 2)**

Participants:

In total 358 adults with subacromial shoulder pain, with ages over 18 years. The number of participants ranged from 20 to 60 [14, 15]. All examined trials included both males and females.

Interventions:

All included RCTs used Mulligan's MWM as an experimental group versus other treatment or no treatment. Nine of included trials used posterolateral mobilization [14, 16, 17, 18, 19, 20, 21, 22, and 23]. Two of included trials used inferior mobilization (Hand behind back) [15, 24]. Five trials compared MWM to exercise using rotator cuff strengthening and scapular stabilization [18]. **Djordjevic *et al.*** [14], **Neelapala *et al.*** [20] and **Satpute *et al.*** [24] used active ROM exercises. Moreover, **Srivastava *et al.*** [21], **Satpute *et al.*** [24] used isometric strengthening exercises. Three trials used sham as a comparator [16, 17, 22]. Two trials examined the effect of shoulder joint mobilization against MWM [18, 15]. One trial compared traditional treatment (exercise, ultrasound, and TENS) with MWM [19]. One trial compared the use of MWM alone to MWM in addition to Kinesio tape [23]. Physician advice only was given in one trial [18].

Outcome measures:

All of the included studies measured change in ROM except **Neelapala *et al.*** [20]**.** Five trials used visual analogue scale (VAS) for measurement of change in pain intensity [21, 19, 20, 24, and 18]. One trial measured change in PVAS [23]. Another one measured change in numerical pain rating system (NPRS) [16]. Two trails used pressure pain threshold (PPT) to measure changes in pain intensity [22, 23]. Four trials estimated upper limb functionality using shoulder pain and disability index (SPADI) [17, 24, 21]. Two trials used Disabilities of Arm, Shoulder, and Hand (DASH) [19, 17]. One trial used SF-36 questionnaire [19]. For evaluating shoulder instability one trial used Oxford Shoulder Instability (OSI) score [15]. One trial measured the changes in shoulder rotators and scapular upward rotation strength [20].

Table (2): Characteristics of included studies

Author/ year	Population				Intervention		Outcome measures	Results
	N	Age	Gender	BMI	Intervention	Control		
KACHINGWE et al.[18]	MWM: 9 Mobilization: 9 Control: 7 Exercise: 8	MWM: 48.9± 13.7. Mobilization: 43.4± 14.7 Control: 45.6 ±13.0 Exercise: 47.3 ±20.1			Posterolateral MWM 10 reps/3 sets.	Control: physician advice. Mobilization: grade I-IV joint mobilizations Exercise: rotator cuff strengthening and scapular stabilization	ROM VAS SPADI	VAS scores revealed statistically significant improvement in pain intensity from pre- to post-treatment on the [F(1,29)=28.5, P<.001ηp 2 =.50, observed power=.99]. On the other hand, no statistically significant differences were found on the interaction between the four groups and mean change from pre to post-treatment
Teys et al. [22]	24	46.1+9.86 (20-64)			postero-lateral glide (MWM). 10 Reps./3 sets.	Sham	ROM PTT	ROM: mean improvement of 16, compared with 4 for the sham and no change for the control. PTT: mean differences between the MWM and Sham 45 kPa and between MWM and Control 46 kPa
Djordjevic et al.[14]	Group 1: 10 Group 2: 10	Group 1: 51.80± 5.3 Group 2: 54.10±6.8	Group 1: 4m/6f Group 2: 3m/7f		Posterolateral glide(MWM). 10 sessions with 24 hours between sessions. a standard 5-cm black Kinesio Tex tape Taping.	Initial exercise program for impingement syndrome: pendulum exercises and pain-limited, active ROM and strengthening exercises	ROM	MWM and kinesotape compared to exercise alone, which resulted in some improvement in ROM but was not statistically significant. By day 10 the mean flexion range was 166±20.59 for the MWM group compared to 86±21.89 for the exercise group, abduction means range was 170±17.89 for the MWM group compared to 60.5±15.72 for exercise only group.
Teys et al. [23]	25	45.4± 14.8.	M/F: 15/10		A single session of posterolateral MWM 10 reps./3 sets followed by a one-week washout. one session of MWM with tape.	A single session of posterolateral MWM 10 reps.//3 sets with tape followed by a one-week washout. a single session of MWM only	ROM PPT PVAS	MWM-with Tape was superior to the MWM as revealed by post hoc test. ROM improved immediately post-intervention, at 24-h and one-week follow-up. the difference in MWM was immediately post-intervention and at 30-min follow-up, but not beyond.
Delgado-Gil et al. [16]	MWM: 21 Sham: 21	MWM: 55.4 ± 7.8 Sham: : 54.3 ± 10			posterolateral MWM 10 reps./3 sets. The approximate length of each treatment session was 10 minutes	The sham condition replicated the treatment condition except for the hand positioning. The approximate length of each treatment session was 10 minutes.	ROM NPRS	Found that pain free shoulder joint flexion ROM, maximum external rotation and maximum shoulder flexion improved significantly after 4 sessions of mobilization. results were better than patients who were in the sham group. Large between-group effect (SMD, 0.9) in favor of the MWM group regarding shoulder pain. Within-group effect sizes were low (SMD <0.26) regarding the abduction.

Satpute *et al.* [24]	MWM: 22 Exercise: 22	MWM: 53.41±7.08. Exercise: 52.41±7.06			MWM (hand behind back),10 reps/ 3 sets. Hot pack. Exercise.	Hot pack. Exercise.	ROM VAS SPADI	Significant difference was found in shoulder internal rotation ROM of 16.86° in the MWM-with-exercise group compared to 7.38° in the exercise group.
Neelapala *et al.* [20]	MWM: 15 Control: 16	MWM: 40.23±10.55 Control: 42.41±10.38			Posterolateral MWM 5 reps./3 sets. 3 sessions.	Active ROM of the shoulder within the pain-free range One set of 10 reps. of active shoulder movements.	VAS shoulder rotator strength, and scapular upward rotation.	Compared to active exercise alone, posterolateral mobilization with movement reduced pain effectively and improved the strength of external rotators inpatients complaining of painful shoulders after 3-5 days. Significant external rotation strength and pain differences were detected between the groups after intervention.
Guimarães *et al.* [17]	MWM: 14 Sham: 13	MWM: 30.3 ± 6.9. Sham: 31.9 ± 9.2.			Posterolateral MWM 10 reps/ 3 sets (4 sessions). Rest and reassessment. Sham condition (4 sessions).	Sham condition (4 sessions). Rest and reassessment. Posterolateral MWM 10 reps/ 3 sets (4 sessions).	ROM DASH SPADI	Sham had a similar effect to MWM in improving shoulder external rotation range and abduction, pain, and function in patients with shoulder impingement syndrome. Only abduction movement and SPADI Pain overcame the clinical relevance threshold. The isometric peak force tests detected no improvement.
Menek *et al.* [19]	MWM: 15 Control: 15	MWM: 51.73 ± 6.64 Control: 50.26 ± 4.28			Posterolateral MWM 10 reps/ 3 sets. Traditional physiotherapy applications	Traditional physiotherapy applications(stretching exercises, cold pack, ultrasound, Transcutaneous Electrical Nerve Stimulation (TENS), finger staircase, Codman and wand exercises)	ROM VAS DASH SF-36	VAS scores during activity and rest, shoulder ROM, and DASH scores in the MWM group were better than the control group ($p < 0.05$)., No statistically significant difference was found in SF- 36.
Kotagiri *et al.* [15]	MWM: 30 Mobilization: 30	MWM: Mobilization:			Inferior MWM 4 times per week (1st day 3 glides, 2nd day 3 sets of six glides, 3rd day 3 sets of 10 glides were given and 4th day again 3 sets of 10)	Mobilizations directed toward the posterior capsule with stabilization exercise. 12 minutes a minimum of 4 times per week	ROM OSI	Mulligan group showed significant improvement in OSI score). ROM showed significant increase in the range of internal rotation by 33.00±7.83degrees compared to 20.83±8.10 degrees.
Srivastava *et al.* [21]	22	MWM: 50.09 ±11.36 Cryotherapy: 41.91 ±11.22			Posterolateral MWM 10 reps/ 3 sets. One session every day.	Cryotherapy 20 minutes . Isometric strengthening exercise	ROM VAS SPADI	**MWM** group VAS (MD) 1st day = 0.9 (MD) 6th day = 2.36 ROM (MD) 1st day = 6.79 (MD) 6th day = 23.63 **cryotherapy** group VAS(MD) 1st day = 0.456 (MD) 6th day = 3.096 ROM (MD) 1st day = 3.13 (MD) 6th day = 21.82

Risk of bias (ROB) in included studies:

For assessing the risk of bias we used Cochrane risk-of-bias tool for randomized trials (RoB 2) Version 22 August 2019 assessment tool [25]. The reviewers had some concerns regarding the risk of bias for 5 of the included studies [16, 17, 18, 22, 23]. 4 studies were rated to be of low risk [14, 20, 21, 24]. Two studies had been rated as high risk [15, 19]. All the studies have no missing data and no non-protocol interventions had been applied **(figure 2)**. Inter-rater agreement was calculated using Krippendorff's Alpha-Reliability (0.955).

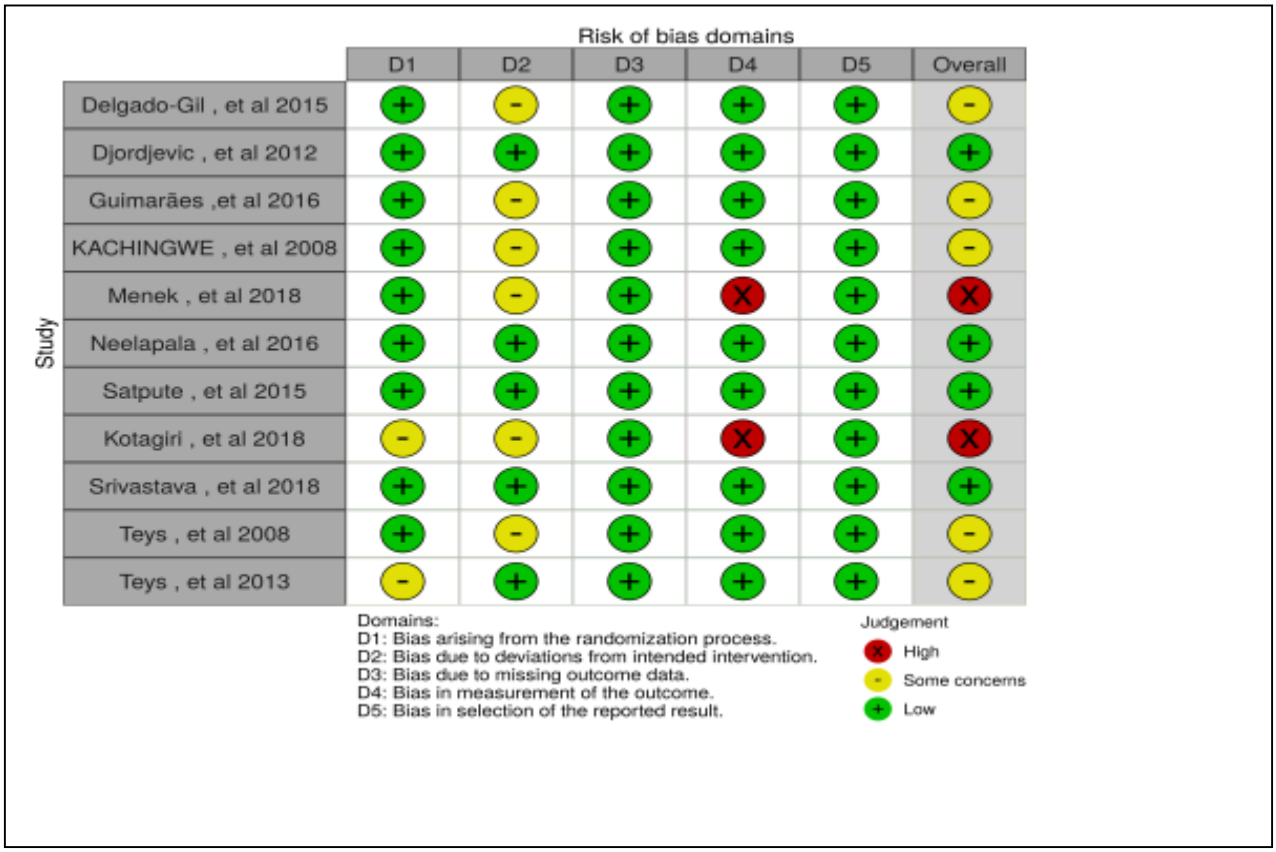

Figure (2): Risk of bias for domains.

Mobilization with movement versus exercise:

Kachingwe *et al.* [18] concluded that if we combined MWM with a supervised exercise program it will result in a better percentage of change (statistically insignificant). VAS percentage of change was 55.2 ± 31.9 after completing the treatment compared to 20.8 ± 112.3 for supervised exercise only. Not only improvement in pain was noted, but also the function was improved in relation to control group or exercise group. VAS test [F (1, 29) = 28.5, P <.001, ηp^2=.50, observed power = .99]. **Djordjevic *et al.*** [14] applied posterolateral MWM and kinesotape compared to exercise alone, which resulted in some improvement in ROM but was not statistically significant. This may be a useful modality in improving the active range of movement in the painful shoulder. By day 10 the mean flexion range was 166 ± 20.59 for the MWM group compared to 86 ± 21.89 for the exercise group, mean abduction range was 170 ± 17.89 for the MWM group compared to 60.5 ± 15.72 for exercise only group. **Satpute *et al.*** [24] detected a statistical significant difference in pain and internal rotation ROM when HBB MWM with exercise applied to individuals complaining of acute shoulder pain and disability compared to hot packs and exercise group. In addition, the difference was of a clinical meaning because it passed the minimum clinically important difference of 1.4 cm on the VAS, 38 the MDC of 6.1° for shoulder internal rotation ROM, and the MDC of 18 points for the SPADI score. **Neelapala *et al.*** [20] found that compared to active exercise alone, posterolateral mobilization with movement reduced pain effectively and improved the strength of external rotators in patients complaining of painful shoulders after 3-5 days. Significant external rotation strength and pain differences were detected between the groups after intervention. After treatment, VAS scores (F (1, 29) = 27, p < 0.01) and Shoulder external rotator strength (F (1, 29) = 4.6, p = 0.04). However, no significant internal rotator strength was detected (F (1, 29) = 0.03, p = 0.8) and scapular upward rotation (F (1, 29) = 0.09, p = 0.7) post-treatment. **Srivastava *et al.*** [21] at the end of six treatment sessions both therapies showed similar results. However, for immediate improvement in ROM and pain,

mobilization can be given to patients with shoulder impingement. MWM group VAS mean diff. (1st day = 0.9, 6th day = 2.36**),** ROM mean diff. (1st day = 6.79, 6th day = 23.63). Exercise/Ice group VAS mean diff. (1st day = 0.456, 6th day = 3.096**),** ROM mean diff. (1st day = 3.13, 6th day = 21.82).

Mobilization with movement versus Sham or no treatment:

Kachingwe *et al.* [18] had patients that only took physician advice and compared them to patients who received MWM combined with supervised exercise program and found a higher percentage of change (without statistical significance) comparing pre- to post-treatment values in decreasing pain and improving function compared to control group. Percentage of change with MWM in VAS was 55.2 ± 31.9 compared to 14.4 ± 119.8. **Teys *et al.*** [22] found that after 3 sessions of MWM can be of benefit to patients with painful limited elevation of shoulder. It lead to an early improvement in ROM and PPT. Mean ROM improvement of 16°, compared with 4°. No change was detected for the control group. Mean PPT differences between the MWM and sham was 45 kPa and between MWM and control was 46kPa. **Delgado-Gil *et al.*** [16] found that pain free shoulder joint flexion ROM, maximum external rotation and maximum shoulder flexion improved significantly after 4 sessions of mobilization. Results were better than sham group patients were. Large between-group effect (SMD, 0.9) in favor of the MWM group regarding shoulder pain. Within-group effect sizes were low (SMD <0.26) regarding the abduction. **Guimarães *et al.*** [17] concluded that sham had a similar effect to MWM in increasing shoulder external rotation range and abduction, improving pain, and function in patients with shoulder impingement syndrome.

Meta-analysis:

To analyze the impact of MWM on subacromial impingement compared to exercise regarding improvement of pain level, four studies qualified for meta-analysis. Unfortunately only the data of VAS scores from three could be obtained (n=3) as one of the authors has been contacted to provide some results but no response detected. A total number of participants was 97 of those 48 who have received MWM, whereas for the impact of MWM compared to sham, SPADI data from two studies were collected (n=2). A total number of participants were 66 of those 3) received MWM.

For VAS a significant statistical difference was detected favoring MWM in the forest plot shown in (Fig. 3) -1.14 (95% CI -2.12 to -0.15) but was below the minimally clinical important difference (MCID) for VAS in patients with rotator cuff diseases, which was 1.4 cm [26]**.** For SPADI a slight difference was detected towards MWM but not significantly shown in (Fig. 4) -6.56 (95% CI -38.56 to 25.43).

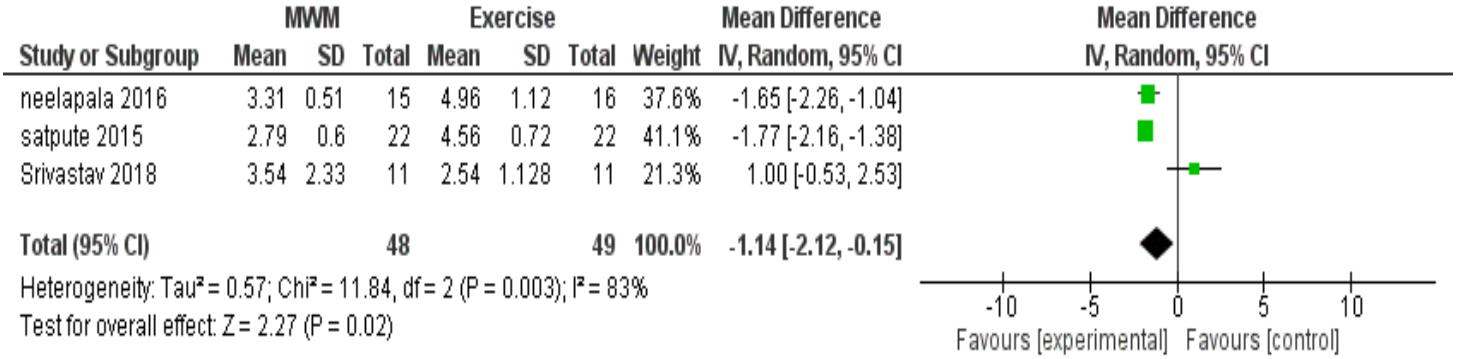

Figure (3): VAS forest plot.

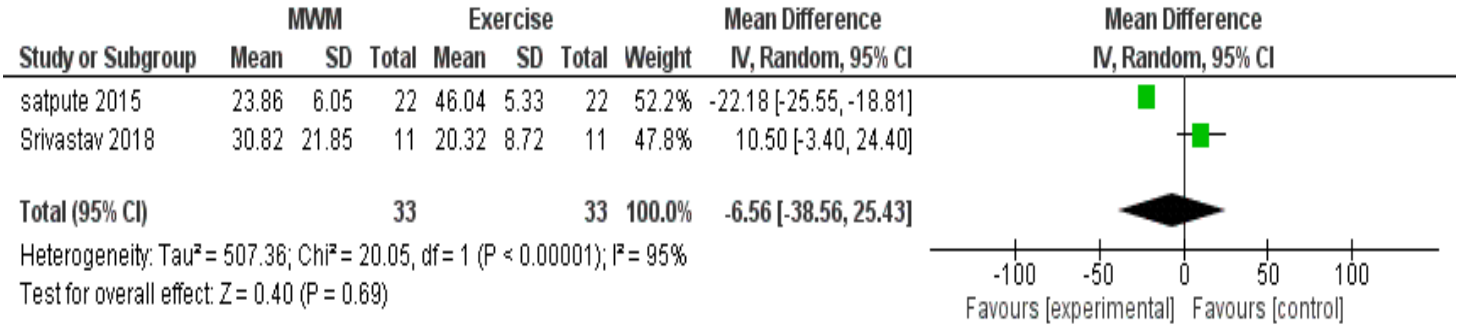

Figure (4): SPADI forest plot.

DISCUSSION

Summary of main results

The current review examined the evidence related to the effects of MWM alone, combined with exercise, joint mobilization, or kinesotape as a treatment for subacromial pain compared to heat therapy, exercise only, mobilization, sham manual contact, and traditional physiotherapy.

Eleven RCTs were contained in the current review. Risk of bias ranged from low to high, which affected the results of our study. Therefore, based on some studies in our review conclusive evidence cannot be reached. The inconsistent findings among studies may be due to lack of a number of the studies in the literature or due to small sample sizes.

Based on the available evidence from ten studies in the current review [14, 15, 16, 18, 19, 20, 21, 22, 23, 24], these results varied among outcomes as MWM was effective at decreasing pain and enhancing outcomes immediately and in short-term ranging from 3 days up to 6 weeks. These findings of improving pain and function agree with the results of previous reviews [11, 27]. On the other hand, one study found that MWM was no better than sham in reducing pain or improving function [17].

Based on 2 RCTs pooled meta-analysis (n=66) on the effect of MWM on shoulder functional outcome, insignificant difference (P>0.05) in changes of SPADI scores was found between MWM and exercise. The presence of high heterogeneity between included studies was (I^2 = 95%) due to the scarcity of included studies subgroup analysis that could not be obtained.

Based on 3 RCTs pooled meta-analysis (n=97) on the effect of MWM on pain score, significant difference was detected (P<0.05) in changes of VAS scores in favor of MWM. The presence of high heterogeneity between included studies was noted among studies (I^2= 83%) because subgroup analysis could not be obtained because of low number of included studies. In addition, the presence or absence of publication bias on these outcomes could not be determined.

From this review, it can be inferred that integrating MWM with shoulder impingement-based exercises produces better outcomes regarding pain and ROM as reported by **Srivastava *et al.*** [21] an immediate improvement has been noted in pain and ROM in the posterolateral MWM group compared to exercise and cold application group. However, there was a similar improvement after completing the treatment in the two groups of pain, ROM, and function. Also, **Neelapala *et al.*** [20] reported not only an improvement of pain level but also in external rotation strength compared to the exercise-only group. However, no significant difference between both groups could be detected in terms of internal rotation strength or scapular upward rotation post-treatment.

Satpute *et al.* [24] added the Hand behind back (HBB) MWM to exercise and found a significant internal rotation ROM improvement, as well as diminished pain and disability. MWM combined with exercise used by **Kachingwe *et al.*** [18] also produced better results compared to both the exercise-only group and control group in pain levels and AROM. Combined with kinesiotape, MWM had a quicker effect than an exercise in improving ROM. On the other hand, by the end of treatment, they both had a similar effect increasing ROM according to **Guimarães *et al.*** [17]. Applying a rigid sports tape immediately after MWM produced a longer-lasting effect than MWM alone up to one week post-intervention regarding improved ROM as described by **Teys *et al.*** [23].

Delgado-Gil *et al.* [16] compared MWM to sham manual contact, which replicated the same hand positioning as the MWM and found that the MWM had a much more significant pain intensity improvement than the sham group during shoulder flexion, pain-free flexion ROM and maximum ROM of both flexion and external rotation. On the other hand, **Guimarães *et al.*** [17] had a completely different conclusion, which is that MWM was no better than sham in reducing pain, improving function, or increasing ROM of shoulder abduction and external rotation. **Teys *et al.*** [22] added that MWM had a much significant difference in ROM and pain pressure threshold than sham manual contact. **Kotagiri *et al.*** [15] tested HBB MWM with stretching against exercise with mobilization on limited internal rotation of the glenohumeral joint and detected a significant difference in internal rotation ROM favoring the MWM group. **Menek *et al.*** [19] examined the value of adding MWM to the traditional physiotherapy applications against traditional physiotherapy applications only (Ice, TENS, US, and exercise) and found a benefit to the addition of MWM to the traditional applications in terms of pain level, ROM, DASH and SF-36.

Strengths and Limitations:

One of the strengths of this review was the use of a meticulous searching strategy and only randomized control trials have been included. To assess the level of bias among the studies of the Cochrane risk of bias, tool (ROB2) was used. To our knowledge, there is no systematic review to date that used MWM for subacromial impingement.

As for limitations, the small number of studies in the literature that investigated MWM for subacromial impingement, small sample sizes for some of the included studies, the potential bias in some of the included studies that arose from lack of blinding, and limitations of pooling data into meta-analysis due to the variability of received interventions between included studies with different outcome measures.

Clinical implications:

Mulligan's mobilization with movement may be beneficial as a part of a multi-modal approach in treating subacromial shoulder pain. As per this review, MWM is more effective with exercise than exercise alone producing short-term improvements in pain, ROM, and functional limitation. Applying a rigid sports tape immediately after MWM can extend the duration of improved symptoms. The short-term effect has to be in mind when constructing a rehabilitative program for those patients. To deduce conclusive evidence more research has to be done on the effectiveness of MWM.

CONCLUSION

Shoulder mobilization with movement combined with a monitored exercise program has a better impact on pain levels, ROM, and functional limitations than exercise alone or sham in short-term with similar long-term improvement to exercise.

RECOMMENDATIONS

More future research with sufficient sample size and appropriate blinding.

Financial support and sponsorship: Nil.

Conflict of Interest: Nil.

REFERENCES

1. **Ludewig P, Cook T (2000):** Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Physical Therapy, 80.3: 276-291.
2. **Conroy D, Hayes K (1998):** The effect of joint mobilization as a component of comprehensive treatment for primary shoulder impingement syndrome. Journal of Orthopaedic & Sports Physical Therapy, 28: 3-14.
3. **Decker M, Hintermeister R, Faber K *et al.* (1999):** Serratus anterior muscle activity during selected rehabilitation exercises. The American Journal of Sports Medicine, 27: 784-791.
4. **Machner A, Merk H, Becker R *et al.* (2003):** Kinesthetic sense of the shoulder in patients with impingement syndrome. Acta Orthopaedica Scandinavica, 74: 85-88.
5. **Michener L, Walsworth M, Burnet E (2004):** Effectiveness of rehabilitation for patients with subacromial impingement syndrome: a systematic review. Journal of Hand Therapy, 17: 152-164.
6. **Bang M, Deyle G (2000):** Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. Journal of Orthopaedic & Sports Physical Therapy, 30: 126-137.
7. **Faber E, Kuiper J, Burdorf A *et al.* (2006):** Treatment of impingement syndrome: a systematic review of the effects on functional limitations and return to work. Journal of Occupational Rehabilitation, 16: 6-24.
8. **Krukowska J, Zbrzezna B, Czernicki J (2009):** Effects of cold on physiotherapy in patients with painful shoulder syndrome. Physiotherapy, 17: 19-27.
9. **Haik M, Alburquerque-Sendín F, Moreira R *et al.* (2016):** Effectiveness of physical therapy treatment of clearly defined subacromial pain: a systematic review of randomized controlled trials. Br J Sports Med., 50: 1124-1134.
10. **Mulligan B (2003):** The painful dysfunctional shoulder. A new treatment approach using "Mobilisation with Movement". New Zealand Journal of Physiotherapy, 31 (3): 140-142.
11. **Stathopoulos N, Zacharias D, George A (2019):** Effectiveness of Mulligan's mobilization with movement techniques on a range of motion in peripheral joint pathologies: a systematic review with meta-analysis between 2008 and 2018. Journal of Manipulative and Physiological Therapeutics, 42: 439-449.
12. **Moher D, Liberati A, Tetzlaff J *et al.* (2009):** The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med., 6(7): e1000097.
13. **DerSimonian R, Laird N (1986):** Meta-analysis in clinical trials. Controlled Clinical Trials, 7 (3): 177-188.
14. **Djordjevic O, Vukicevic D, Katunac L *et al.* (2012):** Mobilization with movement and kinesiotaping compared with a supervised exercise program for painful shoulder: results of a clinical trial. Journal of Manipulative and Physiological Therapeutics, 35: 454-463.
15. **Kotagiri S, Songa A, Gad M *et al.* (2018):** Effectiveness of Mobilization with Exercise V/S Mulligan Internal Rotation MWM with Stretching in Patient with Glenohumeral Internal Rotation Deficit. International Archives of Medicine, 5 (5): 138-145.
16. **Delgado-Gil J, Prado-Robles E, Rodrigues-de-Souza D *et al.* (2015):** Effects of mobilization with movement on pain and range of motion in patients with unilateral shoulder impingement syndrome: a randomized controlled trial. Journal of Manipulative and Physiological Therapeutics, 38: 245-252.
17. **Guimarães J, Salvini T, Siqueira A *et al.* (2016):** Immediate effects of mobilization with movement vs sham technique on a range of motion, strength, and function in patients with shoulder impingement syndrome: a randomized clinical trial. Journal of Manipulative and Physiological Therapeutics, 39: 605-615.
18. **Kachingwe A, Phillips B, Sletten E *et al.* (2008):** Comparison of manual therapy techniques with therapeutic exercise in the treatment of shoulder impingement: a randomized controlled pilot clinical trial. Journal of Manual & Manipulative Therapy, 16: 238-247.
19. **Menek B, Devrim T and CandanAlgun Z (2019):** The effect of Mulligan mobilization on pain and life quality of patients with Rotator cuff syndrome: A randomized controlled trial. Journal of Back and Musculoskeletal Rehabilitation, 32: 171-178.
20. **Neelapala R, Reddy R, Danait R (2016):** Effect of mulligan's posterolateral glide on shoulder rotator strength, scapular upward rotation in shoulder pain subjects–a randomized controlled trial. Journal of Musculoskeletal Research, 19: 1650014.
21. **Srivastava S, Charu E, Harramb M (2018):** Comparison of Mobilisation with Movement and

Cryotherapy in Shoulder Impingement Syndrome-A Randomised Clinical Trial. Journal of Clinical & Diagnostic Research, 12 (10): 1-5.

22. **Teys P, Leanne B, Bill V (2008):** The initial effects of a Mulligan's mobilization with movement technique on a range of movement and pressure pain threshold in pain-limited shoulders. Manual Therapy, 13: 37-42.
23. **Teys P, Bisset L, Collins N *et al.* (2013):** One-week time course of the effects of Mulligan's Mobilisation with Movement and taping in painful shoulders. Manual Therapy, 18: 372-377.
24. **Satpute K, Prashant B, Toby H (2015):** Efficacy of hand behind back mobilization with movement for acute shoulder pain and movement impairment: a randomized controlled trial. Journal of Manipulative and Physiological Therapeutics, 38: 324-334.
25. **Sterne J, Savović J, Page M *et al.* (2019):** RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ, 366: l4898.
26. **Tashjian R, Deloach J, Porucznik C *et al.* (2009):** Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease. J Shoulder Elbow Surg., 18 (6): 927-32
27. **Alalawi A, Alshehri M, Alhasan H (2017):** The Effectiveness of Mulligan's Mobilization with Movement in the Management of Shoulder Impingement Syndrome: A Systematic Review. https://www.researchgate.net/publication/321622245_The_Effectiveness_of_Mulligan's_Mobilization_with_Movement_in_the_Management_of_Shoulder_Impingement_Syndrome_A_Systematic_Review