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Physiotherapy

Physiotherapy 105 (2019) 1–9

Systematic review

Effectiveness of Mulligan's mobilization with movement techniques on pain and disability of peripheral joints: a systematic review with meta-analysis between 2008–2017

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Abstract

Background The Mulligan method of manual therapy advocates the use of 'mobilization with movement (MWM)' techniques to effectively manage peripheral joint 'positional fault' dysfunctions.

Objectives To provide an updated evidence-based systematic review and meta-analysis regarding the effectiveness of MWM techniques.

Data sources PubMed, EBSCOhost, PEDro, Cochrane Library and Google Scholar between 1st August 2008–31st August 2017.

Study selection Two reviewers applied the population intervention comparison outcome (PICO) question to screen the studies for this review. Only RCTs/CCTs were included.

Data extraction Information on study design, subjects, intervention, outcome measures and efficacy results were extracted. Methodological quality was independently assessed by two reviewers using the PEDro Scale.

Data synthesis Sixteen studies with 576 participants were included in four separate meta-analyses for pain and disability. The I^2 index assessed the heterogeneity between studies.

Results MWMs have demonstrated statistically significant improvements against sham treatment, passive and control intervention techniques for pain [mean difference (95%CI): −16.12 (−19.77, −12.48) & $I^2 = 72\%$] and disability [mean difference (95%CI): −17.51 (−22.84, −12.19) & $I^2 = 88\%$] or against another manual therapy treatment [pain mean difference (95%CI): −10.43 (−11.38, −9.48) & $I^2 = 0\%$], however not against another manual therapy treatment for disability. The clinical significance of the pooled differences was compared against Minimal Clinically Important Difference values.

Limitations No long-term effectiveness data were identified in any of the included studies.

Conclusions and implications of key findings The overall post-intervention short-term statistical and clinical significance of MWM techniques has been verified, although the high heterogeneity identified may require further validation of those methods.

Systematic review registration number: PROSPERO 2016:CRD42017071595.

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Keywords: Mobilization with movement; Mulligan Concept; Peripheral; Joints; Manual therapy

Introduction

Brian Mulligan first proposed the theory of joint "positional fault" as a possible malposition between the articular joint surfaces, potentially being the cause of patient symptoms [1,2]. "Positional faults" have very rarely been radiologically verified [3]. Their verification is performed

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https://doi.org/10.1016/j.physio.2018.10.001

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via clinical examination of patients, utilizing the special techniques of the Mulligan Concept [1]. For Mulligan, correction of "positional faults" can lead to successful resolution of symptoms [1,3]. Sympathetic nervous system excitation during the application of manual therapy techniques, including those of the Mulligan Concept [1], may be a complementary explanation for the pain reduction physiological responses noted. Moreover, these effects have been reported to be more pronounced on the same side of the body the technique is applied [4].

For peripheral joints, the Mulligan Concept mainly utilizes the "mobilization with movement (MWM)" techniques, according to which there is a certain direction of application of mobilization forces, which if maintained during a painful movement, the patients' usual pain should be completely resolved. Many repetitions of the pain-free MWM are required to achieve a successful therapeutic result, eventually with the additional application of overpressure, with immediate positive results even within the first treatment session [1]. The mobilization directions for peripheral joints comprise internal and external lateral glide, internal and external rotation and anteroposterior and posteroanterior glide. Regarding the technical terms of the application, mobilizations are implemented with a specified frequency, on specified sets, repetitions and rest periods between them, depending on the joint and the session [1].

In conclusion, the most important points of the Mulligan Concept include the active participation of the patient and the elimination of pain during therapy [1]. These characteristics also ensure the safety of the method. It is worth mentioning that up until now, no significant adverse effects following the application of this method have been reported, as is the case with certain techniques of manual therapy (MT), such as manipulation [5].

Hing *et al*. [6] have conducted a systematic review, focusing on specific joints, yet mentioning aggregate results of MWM for all peripheral joints. This is what inspired the present study, aiming at advancing the research undertaken by Hing *et al*. [6], covering the time period from 2008 until today and conducting a meta-analysis regarding the effectiveness of MWMs for the first time.

The aim of this study was to conduct a systematic literature review with meta-analysis of existing research data concerning MWM, as described in the Mulligan Concept, and examine its effectiveness regarding peripheral joints, between August 2008 and August 2017.

Methods

This systematic review was conducted according to the Preferred Reporting Items for systematic reviews and meta-analyses (PRISMA) guidelines [7].

Search strategy

A comprehensive electronic search strategy of PubMed, EBSCOhost, PEDro, Cochrane Library and Google Scholar was performed for Randomized Controlled Trials/Controlled Clinical Trials (RCTs/CCTs) published within a 9-year period, from 1st August 2008 until 31st August 2017. This systematic review was considered an update of a previous one, by Hing *et al*. [8], which covered the literature prior to August 2008. The search strategy was based on the following medical subject heading (MeSH) search terms: "mobilization with movement" OR "mobilisation with movement" OR "Mulligan method" OR "Mulligan Concept" OR "Mulligan technique". In addition, articles in the reference lists of identified studies were hand searched.

Selection criteria

A PICO question (Appendix A, online supplementary material) was followed in the literature selection process.

Early screening of articles based on titles and abstracts was performed by two authors (NS & GK). The full text of screened articles was studied in case that one of the treatment arms of randomized controlled trials (RCTs) or controlled clinical trials (CCTs) on a peripheral joint musculoskeletal pathology offered Mulligan's MWM and utilized outcomes on either pain or disability. Any relevant study providing results on these domains was included, with outcome measures transformed to a 0–100 scale, if not already presented in these terms, for the purposes of the meta-analysis. Two authors (NS & GK) applied those inclusion criteria independently for study selection and any disagreements were resolved through discussion or the intervention of a third reviewer (ZD).

Specific exclusion criteria were established from the outset for the systematic review. Studies written in other languages than English or Greek were not included. Any study published prior to August 2008 was excluded from the sample; RCTs/CCTs published over the last 9 years were only included to analyze the latest findings on MWMs research. Articles that did not appertain to Mulligan's MWM for peripheral joints were ruled out. Studies on the spinal column, chiropractic, animals and other non-original research papers were excluded. Finally, studies that did not explicitly refer to mobilization with movement of peripheral joints or the rehabilitation of musculoskeletal problems were also excluded from the sample.

RCTs were selected as the most suitable research design for the assessment of the effectiveness of therapeutic interventions [8], which also rank very highly regarding internal validity. They rank second after systematic reviews which only include RCTs in their sample [9]. CCTs were also included though, in an attempt to establish a wider sample, as they also constitute a methodological design of high validity, ranking third after RCTs [9].

Lastly, the reference lists of all articles reviewed were examined by all the reviewers, who sought whether there was another study that would possibly comply with the review requirements and remained unknown to the reviewers.

Assessment of methodological quality

Two reviewers (NS & GK) assessed the methodological quality of the included studies independently to identify potential risks of bias with the PEDro Scale. This scale was employed as it is considered the most suitable one for the critical assessment of RCTs [10,11]. Apart from being widely accepted, this scale has been proven as valid and reliable regarding the assessment of RCTs. The PEDro Scale consists of eleven criteria, ten of which assess the internal validity of studies [10]. The reviewers then compared their individual and total methodological quality ratings and any disagreements were resolved through discussion or the intervention of a third reviewer (ZD). Articles were then classified into three distinct categories, as of high (7–10/10), moderate (4–6/10) and low (0–3/10) methodological quality.

Data extraction

Two reviewers (NS & GK) extracted the following information independently from the included studies: study design, purpose, sample size/group, interventions/group, details of therapeutic intervention(s), assessment timepoints, outcome measures, statistical analysis and results. A predesigned form was used to collect this information.

Meta-analysis

Meta-analysis focused on two dependent variables (outcome measures) and relevant results were collected from the studies included in the sample. Outcome measures on pain and disability were used and presented on a 0–100 scale. For the meta-analysis, the means and standard deviations (SD) of the between-group pre-post differences of each study was used. The mean difference between the two groups under comparison was taken as the effect size for each study, as well as for each meta-analysis [12]. The relevant 95% confidence interval was presented in addition to the effect size for each meta-analysis, as the clinical significance of the analyzed intervention can be determined through a combined consideration of the effect size and the confidence interval [12]. Inverse variance was used for assigning weights to the studies in the meta-analysis [13,14].

The graph of the random effects model was employed for the description of dependent variables for the meta-analyses where the analyzed studies presented a relatively high I^2 heterogeneity index (more than 50%) [15]. In cases where I^2 heterogeneity index was relatively low (less than 50%) the fixed effects model was used [12,15].

The statistical significance of studies was assessed using the Z index of overall effect for each meta-analysis. The clinical significance was assessed based on the comparison of the overall mean difference (95% confidence interval) for each meta-analysis with Minimally Clinical Important Difference (MCID) found in similar studies on peripheral joints [16–18].

Finally, the statistical analysis was conducted through "Review Manager 5.3" software. Review Manager (RevMan) is used for the creation of systematic reviews/meta-analyses and is available on-line by "The Cochrane Collaboration".

Results

Literature review results

Based on all the aforementioned inclusion and exclusion criteria and the design employed for the present systematic review, 14 RCTs and two CCTs were eventually included in the analysis. From the initial database search, 1157 articles were collected (Medline *via* Pubmed: 77, Pedro: 65, Embase: 81, Cochrane: 60, Medline *via* Ebsco: 870 & Google Scholar: 4). Articles were reduced to 44, following the removal of duplicates and the application of the established exclusion criteria after their assessment. After RCTs were identified, they were reduced to 21. Two CCTs were also included. Lastly, four true RCTs that were included in Hing *et al*. [6] and three more articles, namely Chou *et al*. [19], Teys *et al*. [20], and Haider *et al*. [21], were excluded, leading to the final sample of RCT/CCTs ($n = 16$), (Fig. 1). The characteristics of studies included in the sample of the systematic review and meta-analysis are given in detail in Appendix B (online supplementary material).

Methodological assessment of the sample according to the PEDro Scale

All the studies included in the sample were assessed and rated on the basis of the PEDro Scale (Table 1). Consequently, they were classified into three distinct categories, on the basis of the criteria mentioned in the methods. Specifically, seven studies were evaluated as of high methodological quality [22–28], seven of them were evaluated as studies of moderate methodological quality [29–35] and only two of them were evaluated as studies of low methodological quality [36,37].

Meta-analysis

Results regarding pain reduction

For the analysis of the therapeutic results of Mulligan's MWM regarding pain reduction, individual results given in the studies were compared at two levels. The results of MWM were firstly compared with those of a sham, passive or no therapeutic approach (Fig. 2) and then compared with those of another method of MT (Fig. 3).

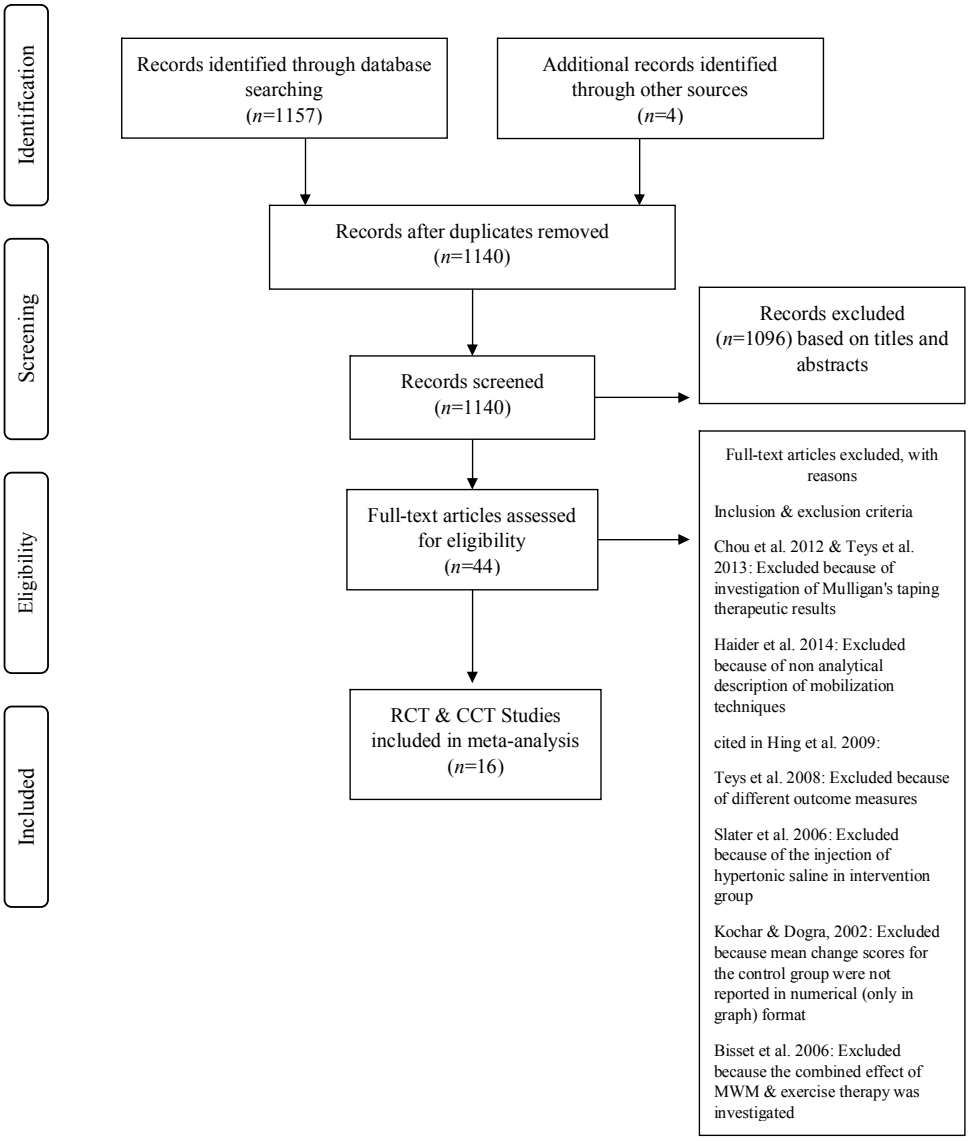

Fig. 1. PRISMA flowchart showing the selection procedure for the studies in this systematic review and meta-analysis.

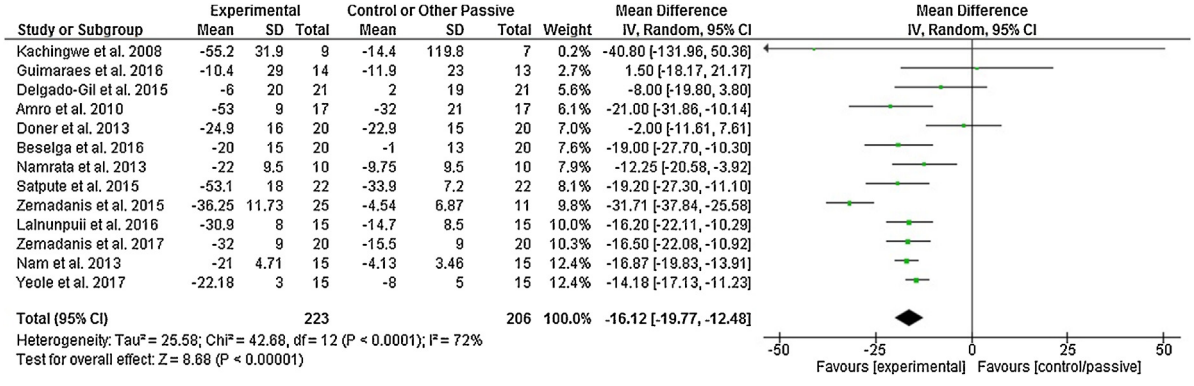

Fig. 2. Forest plots (random effects model) of pain reduction differences between Active MWM Treatment (Experimental) against Control (No, Sham or Passive Treatment). Results lower than zero denote better effectiveness of MWM and higher than zero better effectiveness of the control conditions.

Table 1
PEDro Scale results.

Authors	Random allocation	Concealed allocation	Baseline comparability	Blind subjects	Blind therapists	Blind assessors	Adequate follow-up	Management as planned or intention-to-treat analysis	Between-group comparisons	Point estimates and variability	Total PEDro Score
Kachingwe *et* al. 2008 [32]	Yes	No	Yes	Yes	No	Yes	No	No	Yes	Yes	6/10
Amro *et al.* 2010 [36]	No	No	Yes	No	No	No	No	No	Yes	Yes	3/10
Shrivastava *et al.* 2011 [34]	Yes	No	Yes	No	No	Yes	No	No	Yes	No	4/10
Doner *et al.* 2013 [29]	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5/10
Nam *et al.* 2013 [37]	No	No	Yes	No	No	No	No	No	Yes	Yes	3/10
Namrata 2013 [35]	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4/10
Youssef *et al.* 2015 [33]	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	5/10
Delgado *et al.* 2015 [22]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8/10
Romero *et al.* 2015 [26]	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	7/10
Satpute *et al.* 2015 [23]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9/10
Zemadanis *et al.* 2015 [28]	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5/10
Guimarães *et al.* 2016 [27]	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7/10
Beselga *et al.* 2016 [24]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	8/10
Lalnunpuii *et al.* 2016 [25]	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8/10
Yeole *et al.* 2017 [31]	Yes	Yes	Yes	No	No	No	Yes	No	Yes	No	5/10
Zemadanis *et al.* 2017 [28]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9/1

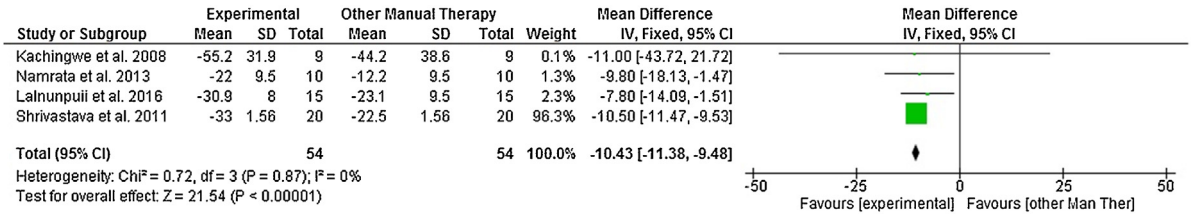

Fig. 3. Forest plots (fixed effects model) of pain reduction differences between Active MWM Treatment (Experimental) against another manual therapy treatment. Results lower than zero denote better effectiveness of MWM and higher than zero better effectiveness of the other manual therapy therapeutic procedures.

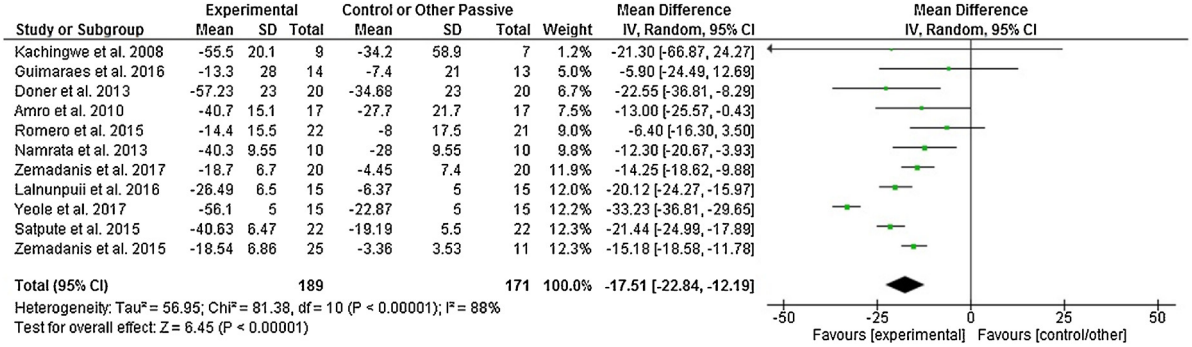

Fig. 4. Forest plots (random effects model) of disability reduction differences between Active MWM Treatment (Experimental) against Control (No, Sham or Passive Treatment). Results lower than zero denote better effectiveness of MWM and higher than zero better effectiveness of the control conditions.

Mobilization with movement (experimental group) compared to a control group (no, sham or passive treatment)

For the comparison of the effectiveness of MWM with a sham, passive or no therapeutic approach, data were collected from thirteen studies ($n = 13$) of the sample, which refer to a total population of 429 participants (223 of whom received MWM therapy). These studies displayed high heterogeneity (I^2: 72%), hence the results are presented based on the random effects model. The outcomes of the meta-analysis displayed statistically significant differences in favor of MWM regarding pain reduction (mean difference [95%CI]: −16.12 [−19.77, −12.48] & Z = 8.68 with $p < 0.001$).

Mobilization with movement (experimental group) compared to another method of MT

For the comparison of the effectiveness of MWM with another method of MT data were collected from four studies ($n = 4$) of the sample, with 54 people per group. The outcomes of the meta-analysis displayed statistically significant differences in favor of MWM regarding pain reduction (mean difference [95%CI]: −10.43 [−11.38, −9.48] & Z = 21.54 with $p < 0.001$). Importantly, these studies present zero heterogeneity (I^2: 0%).

These outcomes appear also clinically significant, when compared to minimally clinically important differences (MCID) presented in other similar studies for hip osteoarthritis pain: −15.3 mm [19] or for rotator cuff shoulder pain: −14 mm [17].

Results regarding disability reduction

Results from individual studies were also combined for the analysis of the therapeutic results of Mulligan's MWM, regarding disability improvement. The results of MWM were firstly compared with those of a sham, passive or no therapeutic approach (Fig. 4) and then compared with those of another method of MT (Fig. 5).

Mobilization with movement (experimental group) compared to a control group (no, sham or passive treatment)

For the comparison of the effectiveness of MWM with a sham, passive or no therapeutic approach, data were collected from eleven studies ($n = 11$), which refer to a total population of 360 participants (189 of whom received MWM therapy). The outcomes of the meta-analysis displayed statistically important differences in favor of Mulligan's MWM, regarding the improvement of the patients' ability (mean difference [95%CI]: −17.51 [−22.84, −12.19] & Z = 6.45 with $p < 0.001$). However, these studies presented high heterogeneity (I^2: 88%).

These outcomes appear also clinically significant, when compared to minimally clinically important differences (MCID) presented in other similar studies for chronic knee disability: −16.0 points for Knee Injury and Osteoarthritis Outcome Score (KOOS) [18], or for knee osteoarthritis: −9.1 points and hip osteoarthritis: −7.9 points for Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC) [17].

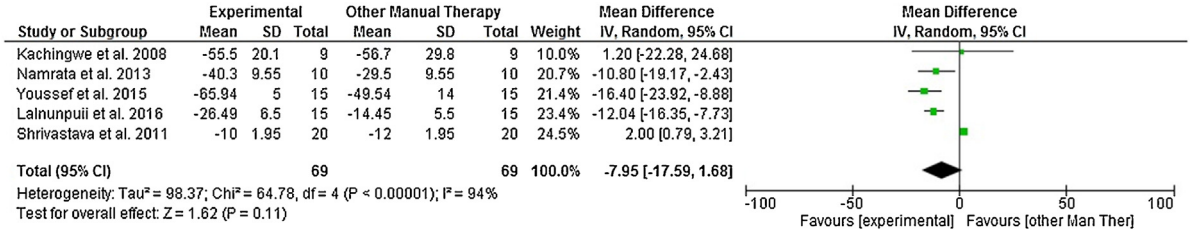

Fig. 5. Forest plots (random effects model) of disability reduction differences between Active MWM Treatment (Experimental) against other manual therapy treatment. Results lower than zero denote better effectiveness of MWM and higher than zero better effectiveness of the other manual therapy therapeutic procedures.

Mobilization with movement (experimental group) compared to another method of MT

For the comparison of the effectiveness of MWM with another method of MT, data were collected from five studies ($n = 5$) of the sample, with 69 people per group. The outcomes of the meta-analysis did not display statistically important differences between Mulligan's MWM and other methods of MT, regarding the patients' disability reduction (mean difference [95%CI]: −7.95 [−17.59,1.68] & Z = 1.62, $P = 0.11$ statistically non-significant). These studies also presented high heterogeneity (I^2: 94%).

Discussion

The outcomes of the present systematic review and meta-analysis appear to concur with the outcomes produced by Hing *et al.* [6] on the effectiveness of Mulligan's MWM, regarding peripheral joints. The strongest indication of our meta-analysis suggests that the therapeutic results of the MWM techniques are important for peripheral joints, regarding pain and disability reduction.

More specifically, it was shown that Mulligan's MWM of peripheral joints, offers better therapeutic results in comparison with a sham, passive or no therapeutic approach, regarding pain reduction. This conclusion emerged from data collected from thirteen studies ($n = 13$) of our sample, which refer to a total population of 429 participants (223 of whom received MWM). However, the authors should remain skeptical regarding pain reduction, as the included studies displayed high heterogeneity ($I^2 = 74\%$) [38]. Moreover, regarding pain reduction in peripheral joints, MWMs appear to produce more significant therapeutic results compared to other methods of MT. It is worth mentioning that the therapeutic results produced by MWM on peripheral joints, as described in the Mulligan Concept, seem clinically significant as compared with a sham, passive, no therapeutic approach or other methods of MT [16,17].

It is worth mentioning the rationale behind including the studies conducted by Lalnupii *et al.* [25] and Saptute *et al.* [23] in the first comparative category; even though an exercise program was implemented on the first control group, rendering it an active therapeutic approach, the same exercise program was also implemented on the research group that additionally followed Mulligan's MWM. Hence, MWM constituted the only factor upon which the differences between the groups were dependent.

Furthermore, it appears that MWM of peripheral joints, as described in the Mulligan Concept, produces better therapeutic results in comparison to a sham, passive or no therapeutic approach regarding disability reduction. The outcomes collected from this comparison also appear to be clinically significant [16,18]. On the other hand, when compared to other methods of MT, they did not appear to have statistically significant greater therapeutic results regarding disability reduction. The authors should remain skeptical about the therapeutic results of Mulligan's MWM regarding patients' disability, as studies included in the sample displayed high heterogeneity (>75%) [38].

To summarise, it seems that there are certain statistically and clinically significant therapeutic results produced by MWM, as described in the Mulligan Concept, regarding peripheral joints. More specifically, it was shown that in comparison to a sham, passive, "sham treatment" or no therapeutic intervention or other methods of MT, Mulligan's MWM produced better therapeutic results regarding pain and disability reduction of peripheral joints. It was also noted that the differences between Mulligan's MWM and other methods of MT were smaller than between Mulligan's MWM and sham, passive, or no therapeutic intervention in therapeutic results. However, as already mentioned, the authors should remain skeptical about the therapeutic results of Mulligan's MWM regarding the reduction of disability of peripheral joints, due to the high heterogeneity observed among the studies used in the meta-analysis.

Comprising only RCTs and CCTs, the sample of the present systematic review and meta-analysis enables the analysis of high-level research evidence, thus increasing the internal validity of the present study and its conclusions. Moreover, the fact that the present study involves a significant number of studies ($n = 16$) and a meta-analysis of their outcomes, which are produced from a relatively large sample set (576 participants) bears a positive impact on the increase of the external validity of the conclusions drawn in the study and their generalizability as regards the general population. On the other hand, a limitation is that the sample used in the study only comprises RCTs and CCTs, hence excluding a significant number of studies which employ a different

Key messages

- A systematic review/meta-analysis of the MWM Mulligan concept manual therapy methods
- Sixteen RCT/CCT studies published over the last 9 years were used to analyze the immediate post-application effectiveness of MWMs on pain and disability; techniques are effective under this framework.
- New RCTs are required, to include the long-term effectiveness of MWMs as well as to test more functional applications of the techniques, also under a form of home-based self-mobilization program.

methodological design. Also, another limitation is that in the meta-analyses that compared MWM to other MT, there are very small numbers in some of the pooled comparisons.

Future research in this area could focus on the effectiveness of the other MWM techniques which are described in the Mulligan Concept which remain unexplored. Moreover, research studies on the therapeutic results of MWM techniques implemented on peripheral joints which remain unstudied, such as the wrist joint could be performed. Furthermore, longer follow-up time periods for examining the long-term effectiveness of the therapeutic results produced by the specific mobilization techniques would be quite valuable. Also, research on the effectiveness of self-therapy techniques (self-MWM) described in the Mulligan Concept regarding peripheral joints, as well as of MWMs performed in functional loading positions for the upper and lower limbs is yet unexplored.

Conclusion

Mobilization with movement, as described in the Mulligan Concept, produces certain statistically and clinically important therapeutic results regarding peripheral joints. Mulligan's MWM appeared to produce better therapeutic results in terms of statistical and clinical importance, regarding pain and disability reduction of peripheral joints, compared to a sham, passive, "sham treatment" or no therapeutic intervention and for pain reduction compared to other methods of MT. Due to the high heterogeneity displayed among the studies used in individual meta-analyses, and the non-statistically significant differences found in certain meta-analyses, the therapeutic results of Mulligan's mobilization methods should be further examined in future studies of high methodological quality.

Conflicts of interest: None declared.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.physio.2018.10.001.

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