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The use of manual lymphatic drainage on clinical presentation of musculoskeletal injuries: A systematic review

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ABSTRACT

The aim of this study was to provide a systematic review on the applicability of manual lymphatic drainage (MLD) in improving edema and clinical presentation postmusculoskeletal injuries. A review of the literature was performed in CINAHL, MANTIS, Medline, SPORTDiscus and Google Scholar, yielding a total of 8 articles. Half of the studies showed a strong quality assessment. Results from our work support the use of MLD for reducing edema reduction and pain as well as enhancing range of motion and patients' quality of life and satisfaction. Further research is needed to apply these findings to a broader range of musculoskeletal injuries and conditions.

1. Introduction

Worldwide, musculoskeletal disorders, which include injuries and disorders of the muscular (muscles, tendons, nerves) and skeletal (bones, joints, ligaments, cartilage and disks) systems affect tens of millions of individuals [1]. Disability due to musculoskeletal disorders is estimated to have raised by 45% from 1990 to 2010 and is still rising due to an increased prevalence of obesity and sedentary behaviors, and general ageing of the population [2,3]. While the prevalence of musculoskeletal disorders increases with age, younger people are also affected, often during their peak income-earning years [3]. These types of disorders often develop during leisure time activities and sports, with adolescents predominantly representing this category, as well as during professional tasks, with 25% of workers reporting important deficits yearly [4].

Musculoskeletal disorders can be of traumatic nature or occur over time due to stress placed on muscles, tendons, ligaments, and various other structures. Although they may vary in location, type, and degree of severity, they can be classified in two different categories: macrotraumatic and microtraumatic disorders. The former result from acute trauma and include fractures, dislocations, subluxations, sprains, strains and contusions whereas the latter result from overexertion and repetitive motion and include tendinitis, tenosynovitis, bursitis, etc. [5].

Musculoskeletal disorders are a major cause of loss of productivity in the workplace [6] and functional capacity limitations [2] and may negatively affect quality of life on both physical and psychological standpoints [2]. Although the clinical presentation of musculoskeletal disorders and their effect on functioning are as unique as individuals sustaining them, almost all of these conditions follow a similar initial basic physiologic healing pathway [7]. Indeed, the healing process begins immediately after a tissue is injured by initiating the inflammatory response during which symptoms such as redness, swelling, and pain, increased temperature and tenderness will appear [7]. The inflammatory response serves to protect the injury site and to prepare the area for healing by disposing of injury by-products such as blood and damaged cells and by increasing blood vessels permeability at the site of injury [7]. Despite resulting in edema, or swelling, this physiological response is essential as it allows to bring proteins and white blood cells to the injury site, setting the table for tissue repair [7]. Although essential for short-term healing, the inflammatory response phase may cause pain, stiffness and decreased function if edema lingers in damaged tissues beyond the inflammatory response phase [8]. This phenomenon can occur in disorders that are poorly managed, or in individuals with pre-existing conditions, where physiological processes struggle to evacuate edema from the injury site.

In order to support these processes and optimize return to daily activities including physical, sports, leisure and professional activities,

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different therapeutic modalities are available to clinicians working with musculoskeletal conditions [7]. These modalities include cryotherapy, compression and elevation, electrophysical agents, massage therapy to name a few [7]. More specifically, massage therapy is a technique commonly use to decrease the pain associated with various types of musculoskeletal disorders. With skin contact at the common base of all massage techniques, it aims to stimulate somatosensory receptors in hopes to assist specific physiological responses [8].

For example, the lymphatic system, which plays an important role in the healing process by picking up edema from injury sites, requires a force equal to or less than 60 mmHg to allow for the recuperation of inflammation by-products from edematous sites [9]. To achieve this intended effect, the skin contact must consist of motions that move the skin without stroking or sliding over it [8]. Such motion can be attained through a specific type of massage therapy, referred to as manual lymphatic drainage (MLD).

In MLD, movements of the hand are used to stretch the skin in a specific direction and to promote variations in interstitial pressures, aiming to enhance the filling and emptying of lymph vessels and over all contributing to improve transport of fluid [10]. These movements are slow, repetitive and usually incorporate a brief resting phase, allowing the skin to return to its initial position [8]. This skin stretching and resting combination is effective on lymph collectors and local smooth muscles, by increasing the frequency of contraction of the lymphangion and the lymphatic transport capacity [8,11]. In addition to reducing edema, MLD is suggested to decrease pain via several mechanisms. First, it stimulates a general parasympathetic response, which results in relaxation [8]. Second, rhythmic, intermittent and gentle pressures stimulate large diameter proprioceptive and cutaneous receptors, which may block messages transmitted to the central nervous system, through the gate control theory [7]. Finally, MLD increases the absorption of nociceptive chemical stimulants such as lactic acid, cytokines and inflammatory mediators from the interstitial environment [8].

This technique is generally used with clients suffering from lymphedema, a build-up of lymph fluid in an upper or lower limb. The main available body of literature on MLD suggests that this technique, or its combination with the use of compressive garments, significantly reduces the volume (i.e. edema) of the area treated in patients with various medical conditions [12] by significantly increasing lymphatic activity [13]. For instance, MLD has widely been used and validated in treatment of lymphedema following breast cancer treatment or mastectomy. A systematic review published in 2020 [14] reported that MLD had favorable effects on volume reduction, quality of life and symptom-related outcomes. Some results also suggested a reduction in the incidence of lymphedema in at-risk patients with the use of MLD in early rehabilitation post-surgery [14]. However, little evidence currently exists on the use of MLD in the context of musculoskeletal disorder management and its effectiveness in reducing localized edema, and improving overall clinical presentation. In a recent systematic review by Doubblestein and colleagues [15], it was shown that MDL could potentially be a suitable option in managing musculoskeletal conditions [15]. Of the five studies included (192 patients in total), three focused on acute musculoskeletal disorders (e.g. arthroplasty, amputation) while the remaining two focused on subacute edema (e.g. tibial fracture) Authors concluded that MLD may be effective to reduce edema and improve range of motion (ROM) when combined with auxiliary therapies. Although the literature provide insight on the potential contribution of MLD on edema control in a wide range of musculoskeletal conditions, limited information if currently available for clinicians wishing to use this technique in the management of edema and clinical presentation specific to musculoskeletal injuries.

Hence, there was a need for a systematic review of the literature aiming to study the effects of MLD on edema control and overall clinical presentation limited to musculoskeletal injuries caused by macro- or micro-trauma. The objective of this study was therefore to conduct a systematic review of the literature in order to find out whether the use of MLD in the context of the management of musculoskeletal injuries is more effective than other therapeutic approaches in reducing edema and improving clinical presentation.

2. Methods

The elements of the research question were based on the Participant, Intervention, Comparison, Outcome (PICO) framework [16]. The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines [17] were used to conduct this review. The following databases were searched prior to elaborating the research question to ensure it had not already been answered in the literature: Cochrane, Prospero and Joanna Briggs Institute.

2.1. Search strategy

The search strategy was applied to the following databases: CINAHL, MANTIS, Medline and SPORTDiscus as well as Google Scholar, with no date limit. Search strategy was performed in August of the year 2020. The research was oriented using the following concepts and keywords ensembles and Boolean search terms: 1) manual lymphatic drainage AND 2) musculoskeletal injuries AND and 3) clinical presentation. The reference sections of the publications obtained through this search were equally inspected to identify potential additional studies not found through the database searches. The reference list from each individual search was imported into Endnote X9for reference management.

2.2. Selection criteria

The PICOS (population, intervention, comparison, outcome, study design) framework [16] was used to guide this review.

2.3. Population

The population of interest was patients with musculoskeletal injuries due to sports or work accidents in either or both upper and lower extremities. Studies were excluded if patients presented other dysfunctions or pathologies, such as cancer, fibromyalgia or lymphedema.

2.4. Intervention

The intervention was MLD treatment for edema control alone or combined with other treatment modalities.

2.5. Comparison

Eligible comparators were physiotherapy treatment or conventional treatment (including elevation, active and passive exercises, compression and functional training) or other treatment modalities (ice, kinesiotaping, etc.).

2.6. Outcome

Relevant outcomes were edema, pain, ROM, function and participants' satisfaction.

2.7. Study design

Primary studies of any design were eligible, except case studies and reports. Abstract, conference proceedings, personal correspondence, letters to the editor, review articles and non-comparative studies were excluded.

2.8. Study selection and data extraction

Study selection was limited to studies published in English or French, with no time limit. Eligibility of potentially relevant article was performed by two independent reviewers (AMP and EGL) through an unblinded screening approach of each reference using AbstrackR [18]. Discrepancies in study selection were resolved by a third reviewer (LACB). Data extraction tables were created in Excel. Data were independently extracted by the principal investigator (AMP) and one of the co-investigators (EGL or EC). Content expert (LACB and SMR) then independently verified the extracted data. The following data were extracted: authors, study characteristics (country, date of publication, study design), type of injury, sample size, population characteristics (age, % female), experimental treatment (modality, frequency and number of treatments), control treatment and outcomes measures (ROM of motion, function and participants' satisfaction).

2.9. Quality of evidence assessment

The quality of each study was independently evaluated by the principal investigator (AMP) and one of the co-investigators (EGL or EC) using the Quality Assessment Tool for Quantitative Studies EPHPP [19], with content expert (LACB) acting as a moderator in case of disagreement. Content expert (LACB and SMR) then independently verified the quality assessment. The EPHPP was developed to assess the scientific quality and rigor of articles pertaining to a wide range of health-related topics. To reach a scientific conclusion, this quality assessment tool uses a number of criteria to give a mark ranging between 'strong', 'moderate', and 'weak' in eight different categories: selection bias; study design; confounders; blinding; data collection practices; withdrawals and dropouts; intervention integrity and analysis [19]. Once the assessment is done, the score of each category is computed to obtain a global result of the study quality, again ranging between 'strong', 'moderate', and 'weak'.

3. Results

3.1. Study selection

A PRISMA diagram of the search results, including reasons for exclusion, is presented in Fig. 1. A total of 5394 articles were retrieved from the database research and 14 additional studies were found through Google Scholar. 3120 duplicates were removed, leaving a total of 2288 articles to be screened for eligibility. With a selection consistency between the reviewers (AMP and EGL) of 94% at the title/abstract level, only 34 studies had to be reviewed by a third-party to achieve consensus (LACB). A total of 12 articles then underwent full text review. Three articles were excluded for not meeting the population criteria (two included patients with fibromyalgia or amputation, one was an animal study), and one article was excluded because of language (published in Spanish). A total of 8 articles were included in the systematic review.

3.2. Study characteristics

Overall, eight studies (n = 337 participants) from seven countries (Danmark, Australia, Switzerland, Sweden, United States, Italy and France), published between 1988 and 2020 were included. Among included studies, there were five randomized controlled trial (RCTs), two randomized crossover trial and one prospective study. Four studies focused on the effect of MLD following knee arthroplasty while the remaining focussed on the effects of MLD on hand edema (three after fracture of the radius and one for general hand edema). The interventions used for these studies varied in frequency (from one treatment only to up to three times a week for four weeks) and duration (from 5 to 45 min for a treatment session). The vast majority of these studies (n

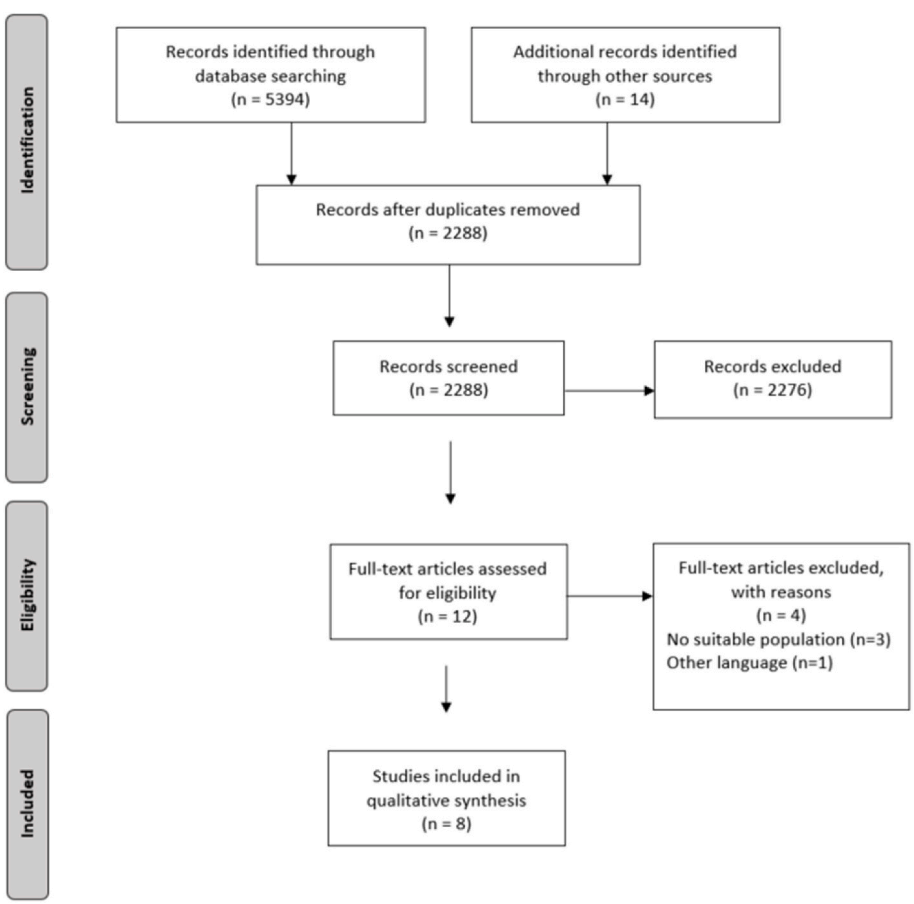

Fig. 1. PRISMA 2009 flow diagram.

= 5) compared the effect of the combination of MLD treatment with other treatment modalities (conventional, concomitant physical therapy or traditional edema treatment [elevation, compression, and functional training]) to the effect of standard care or control intervention, while the remaining studies compared the effect of MDL treatment alone to cryotherapy (n = 1), string wrapping (n = 1) or kinesiotaping (n = 1). All of the eight selected studies reported data on edema (measured by girth or limb volume), five reported data on pain (measured with a numeric rating scale), four reported data on ROM (measured in degree or with Pulpa Vola Distance and thumb carpometacarpal opposition) and three reported data on function and satisfaction (measured by gait parameter, the Knee injury and Osteoarthritis Outcome Score (KOOS) [20], a validated measure evaluating patient-related outcome post-knee surgery [21], the Questionnaire for bilateral activities, designed by the authors of the study [22] to evaluated the patient activities of daily living levels or with the Canadian Occupational Performance Measure (COPM) [23], a validated measure used to assess patients perceived performance of daily activities and their satisfaction with their performance [24]) (refer to Table 1 for study characteristics).

3.3. Quality of evidence assessment

Overall, the quality of evidence ranged from 'weak' to 'strong' on the EPHPP assessment tool. Two studies scored 'weak', two studies scored 'moderate' and four studies scored 'strong' (Table 2). The most problematic items were related to blinding for failing to report whether outcome assessors and/or participants were blinded to the intervention (a 'weak' or 'moderate' score was attributed to 7 out of 8 studies), and to selection bias for failing to select individuals likely to be representative of the target population (a 'weak' or 'moderate' score was attributed to 4 out of 8 studies). A 'strong' score was attributed to the majority of the studies (≥6 studies out of 8) for study design (most selected studies were designed as RCT), confounders (there were no important differences between groups prior to the intervention), data collection (measures

Table 1
Study characteristics of included articles.

First author, Year CountryStudy design	Injury type	Sample Size (n) Sex (% female)	Age ± SD (yrs)	Experimental treatment	Control treatment	Outcomes	Time of measures
Tornatore et al., 2020 Italy RCT	Total knee arthroplasty	E: MLD n = 33 (79%) C: Ktaping n = 33 (76%) C: MDL & Ktaping n = 33 (73%)	E: MLD 71,3 ± 7,09 C: Ktaping 72,8 ± 7,34 C: MDL & Ktaping 69,9 ± 5,85	30 min of MLD session on day 2 and day 4 post-surgery combined with standard care (2x/day)	Ktaping on day 2 and day 4 post-surgery) combined with standard care (2x/day) or the combination of MLD, ktaping and standard care	Edema Pain ROM	4 and 6 days post-surgery
Pichonnaz et al., 2016 Switzerland RCT	Knee arthroplasty (total)	E: n = 30 (60%) C: n = 30 (70%)	E: 71,3 ± 8,8 C: 70,1 ± 9,12	5 × 30 min of MLD sessions between day 2 and day 7 post-surgery, combined with standard care	5 × 30 min of tape-recorded relaxation sessions based on Ericksonian hypnosis and autogenic training combined with standard care	Edema Pain ROM Gait	7 days and 3 months post-surgery
Ebert et al., 2013 Australia RCT	Knee arthroplasty (total)	E: n = 24 (29%) C: n = 26 (27%)	E: 70,8 C: 69,2	30 min MDL on days 2, 3 and 4 postoperatively combined with standard care	Standard care (physical therapy) 2x/day for 3 first days and 1x/day from day 4 to hospital discharge	Edema Pain ROM KOOS	2, 3, 4 days and 6 weeks post-surgery
Cavarec et al., 2012 France Crossover CT	Knee arthroplasty (total or partial)	n = 8 (N/A)	70,8 ± 8,65	30 min MLD treatment	30 min cryotherapy	Edema Pain	before and after both treatments
Knygsand-Roenhoej & Maribo, 2011 Denmark RCT	Hand/arm edema following distal radius fracture	E: n = 14 (71%) C: n = 15 (73%)	E: 64,4 ± 9,5 C:62,7 ± 9,7	3x/week for 4 weeks then 2x/week for 2 weeks of MEM to the trunk region, followed by MEM pump points stimulation to the involved UE and home exercises.	3x/week for 4 weeks then 2x/week for 2 weeks of standard care, Coban wrapping and home exercises	Edema Pain ROM Satisfaction ADL performance	1, 3, 6, 9 and 26 weeks after inclusion
Härén &Wiberg, 2006 Sweden RCT	Hand/wrist edema following distal wrist fracture	E: n = 25 (84%) C: n = 26 (81%)	E: 62 C: 63	6 treatments of 40 min of MLD combined with standard care	6 treatments of 40 min of standard care	Edema	13 days and at 2 months after inclusion
Härén et al., 1999 Sweden Prospective study	Edema following external radius fracture	E: n = 12 (83%) C: n = 14 (71%)	E: 60 C: 61	10 sessions of 45 min MLD as described by Vodder combined with standard care	10 sessions of 45 min of standard care	Edema	3, 17, 33 and 68 days after the external fixation was removed
Flowers, 1988 United States crossover RCT	Generalized hand edema	n = 14 (71%)	Range: 24 to 61	5 min treatment with traditional retrograde massage randomly performed on one finger	5 min of one of the following 1) string wrapping 2) string wrapping with continuous superimposed retrograde massage 3) string wrapping with intermittent superimposed retrograde massage on remaining fingers	Edema	before and after each of the two or four treatments

ADL Activities of daily living, C Control group, CT controlled trial, E Experimental group, ktaping Kinesiotaping, KOOS knee injury and osteoarthritis outcome score, MEM Modified manual edema mobilization, min Minutes, MLD Manual lymphatic drainage, RCT randomized controlled trial, ROM Range of motion, UE Upper extremity.

Table 2
Quality assessment of included studies based on the Effective Public Health Practice Project (EPHPP) assessment tool.

First author, Year Country Study design	Selection bias	Study design	Cofounders	Blinding	Data collection methods	Withdrawals and drop-outs	Global rating	Interpretation
Tornatore et al.,2020 Italy RCT	1	1	1	3	1	1	**2**	**Moderate**
Pichonnaz et al., 2016 Switzerland RCT	1	1	1	2	1	2	**1**	**Strong**
Ebert et al., 2013 Australia RCT	1	1	1	2	1	1	**1**	**Strong**
Cavarec et al., 2012 France Crossover CT	3	3	3	3	1	1	**3**	**Weak**
Knygsand-Roenhoej & Maribo, 2011 Denmark RCT	1	1	1	2	1	1	**1**	**Strong**
Härén &Wiberg, 2006 Sweden RCT	2	1	1	1	1	1	**1**	**Strong**
Härén et al., 1999 Sweden Prospective study	2	1	1	3	1	1	**2**	**Moderate**
Flowers, 1988 United States crossover RCT	3	2	3	3	3	3	**3**	**Weak**

CT Controlled trial, RCT Randomized controlled trial, 1 Strong, 2 Moderate, 3 Weak.

were valid and reliable), and withdrawal and drop-outs (the vast majority of the participants [80–100%] completed the proposed interventions).

3.4. Synthesis of data

Due to the significant heterogeneity of the included articles in this review, a narrative approach was opted for data presentation (refer to Table 3 for extracted results of included studies and Table 4 for summary of effects of MLD).

3.5. Edema

Data on edema were collected in all of the eight included studies that used MLD alone or combined with other treatment modalities. In one of them [25], decrease in edema was significantly greater when the intervention included solely MLD as opposed to other treatment modalities, while in four of them [25–28], a greater effect was observed when MLD was combined to other treatment modalities. Tornatore et al. [25], who measured peri-articular knee girth after total knee arthroplasty, demonstrated that MLD alone, or combined with kinesiotaping, significantly decreased edema when compared to kinesiotaping alone (control group) up to 6 days following surgery. Similar findings were reported by Härén et al. and Härén & Wiberg [27,28] who studied hand and wrist edema following distal arm or wrist fracture. Both studies reported that MLD combined to standard care offered a greater reduction in limb volume when compared to standard care alone within 17 days of external fixation removal. Flowers [26] reported results showing a greater reduction in hand edema with retrograde massage, a form of MLD, combined with string wrapping when compared to massage or string wrapping alone. The other four remaining studies [22,29–31] did not show a greater effect of the experimental intervention on edema (i.e. MLD alone or combined to other treatment modalities) when compared to the control interventions.

When looking only at the effect of pre-versus post-MLD treatment (alone or combined to other treatment modalities) on edema (i.e. within-group effect), significant reductions were reported for knee edema (MLD combined with standard care [30] and MLD alone [31]) and for hand edema (MLD alone [22] and MLD combined with standard care [28]). Four studies [25–27,29] did not report results regarding within-group effects.

3.6. Pain

Data on pain were collected in five of the eight included studies [22,25,29–31] that used MLD alone or combined with other treatment modalities. In one of them [25], a decrease in pain was significantly greater when intervention included MLD combined to other treatment modalities. Indeed, Tornatore et al. [25], which measured pain after total knee arthroplasty, demonstrated that MLD combined with kinesiotaping, significantly decreased pain when compared to MLD or kinesiotaping alone (control group) up to 6 days following surgery. The other four remaining studies [22,29–31], did not show a greater pain reduction after the experimental interventions (i.e. MLD alone or combined to other treatment modalities) when compared to the control intervention (relaxation, standard care in the form of physical therapy and cryotherapy).

When looking only at the effect of pre-versus post-MLD treatment (alone or combined to other treatment modalities) on pain (i.e. within-group effect), four studies out of five reported significant reductions after MLD (alone or combined). Three of the four studies demonstrated knee pain reduction after partial or total knee arthroplasty (MLD combined with standard care [29,30] and MLD alone [31]). While the remaining study reported significant reduction in pain after MLD alone in patients having sustained a distal radius fracture [22]). The fifth study [25] did not report within-group effects.

3.7. Range of motion (ROM)

Data on ROM were collected in four of the eight included studies [22,25,29,30] that used MLD alone or combined with other treatment modalities. In one of them [30], an increase in knee flexion at day 4 up to 6 weeks post-knee surgery was significantly greater in the intervention group (MLD combined to standard care) when compared to control intervention (standard care). A decrease in knee contracture at 3 months post-knee surgery that was significantly greater in the intervention

Table 3
Extracted results of included studies.

First author, Year Country Study design	EDEMA Measure & Results	PAIN Measure & Results	ROM Measure & Results	FUNCTION & SATISFACTION Measure & Results
Tornatore et al., 2020 Italy RCT	Girth (cm) Significant reduction in girth at day 4 and 6 post-surgery over and under the knee and at the ankle in the group combining MDL & Ktaping when compared to MLD or Ktaping only ($p < 0.005$ for all mentioned measures). Significant reduction in girth at day 4 post-surgery over the knee ($p = 0.05$) and at day 4 and 6 post-surgery under the knee ($p = 0.049$; $p = 0.015$, respectively) in the MLD only group when compared to Ktaping only. No within-group difference reported	NRS (0–10) Significant reduction in pain at day 4 and 6 post-surgery in the group combining MLD and Ktaping when compared to MLD or Ktaping only ($p < 0.006$ for all mentioned measures). No significant difference between MLD and Ktaping. No within-group difference reported.	ROM (°) No significant difference between the three groups.No within-group difference reported.	N/A
Pichonnaz et al., 2016 Switzerland RCT	Limb volume difference (mL) No significant difference in limb volume between groups at days and 7 and 3 months post-surgery. No within-group difference reported.	NRS (0–10 mm) No significant difference in pain between groups at day 2 and 7 and at 3 months post-surgery. Significant decrease in pain in the MLD group between the 4th and 5th treatment (p value not reported).	ROM (°) No significant difference in ROM between groups at day 7 post-surgery. Significant decrease in knee contracture at 3 months post-surgery in the MLD group when compared to the control group ($p < 0.05$). No within group difference reported.	GAIT No significant difference in gait parameters between groups at day 7 and 3 months post-surgery. No within-group difference reported.
Ebert et al., 2013 Australia RCT	Girth (cm) No significant between-group difference in lower limb girth. Significant decrease in midpatella ($p = 0.001$) and calf girth ($p < 0.001$) over time in both groups.	NRS (0–10) No significant between-group difference in NRS score. Significant decrease in NRS score over time in both groups ($p = 0.007$).	ROM (°) Significant increase in knee flexion in the MLD group when compared to the control group at day 4 ($p = 0.014$) and 6 weeks ($p = 0.012$) post-surgery. No significant between group difference in knee extension. Significant improvement in active knee extension ($p < 0.001$) and flexion ($p < 0.001$) over time in both groups.	KOOS No significant between group differences on each subscale of the KOOS. Significant within groups improvements on the following KOOS subscales: pain ($p < 0.001$), symptoms ($p < 0.001$), ADL ($p < 0.001$), sports and recreation ($p = 0.006$) and quality of life ($p < 0.001$)
Cavarec et al., 2012 France Crossover CT	Girth (cm or mm) No significant between-groups difference in girth. Significant decrease in girth 5 cm above the patella ($p < 0,02$), at the patella base ($p < 0,05$) and at the patella peak ($p < 0,01$) in the MLD group. Significant decrease in girth 10 cm above the patella ($p < 0,01$), 5 cm above the patella ($p < 0,05$) and at the patella peak ($p < 0,01$) in the cryotherapy group.	NRS (0–10) No significant between-groups difference in pain. Significant decrease in pain in the MLD ($p < 0,001$) and cryotherapy ($p < 0,001$) groups.	N/A	N/A
Knygsand-Roenhoej & Maribo, 2011 Denmark RCT	Limb volume difference (mL) No significant between group difference in limb volume at 6 and 9 weeks. Significant decrease in limb volume at 6 weeks in both groups ($p < 0.01$). No within-group difference reported.	VAS (0–100) No significant between group difference in pain at rest and during activity at 6 and 9 weeks. Significant decrease in pain at rest at 6 weeks in both groups ($p < 0.01$). No within-group difference reported.	Pulpa Vola Distance (PV) and thumb carpometacarpal opposition (CMC) No significant between group difference in active PV and CMC ROM at 6 and 9 weeks. Significant increase in active ROM at 6 weeks in both groups ($p < 0.01$) No within-group difference reported.	QBA No significant between group difference in ADL at 6 and 9 weeks. Significant improvement in ACL in the MEM group when compared to the control group at 3 weeks ($p = 0.03$). COPM No significant between-group difference in performance and satisfaction. No within-group difference reported.
Härén &Wiberg, 2006 Sweden RCT	Limb volume difference (mL) Significant reduction in limb volume in the MLD group when compared to the control group at the first measurement ($p = 0.005$). No significant between-group difference in limb volume at the second measurement. Significant reduction in limb volume in both the MLD and control group (CI = 10–55; CI = −10-45) at the first measurement. Significant reduction in limb volume	N/A	N/A	N/A

(*continued on next page*)

Table 3 (*continued*)

First author, Year Country Study design	EDEMA Measure & Results	PAIN Measure & Results	ROM Measure & Results	FUNCTION & SATISFACTION Measure & Results
	in both the MLD and control group (CI = 10–90; CI = 15–80) at the second measurement.			
Härén et al., 1999 Sweden Prospective study	Limb volume difference (mL) Significant decrease in hand volume in the MLD group when compared to the control group at the first and second measurements (p = 0.04; p = 0.02). No significant between-group difference at the third and fourth measurements. No within-group difference reported.	N/A	N/A	N/A
Flowers, 1988 United States crossover RCT	Average circumference reductions (%) Significant improvement in combined massage and string wrapping when compared to massage only (p = 0.01) or intermittent combined massage and string wrapping (p = 0.05). Significant improvement in intermittent combined massage and string wrapping when compared to string wrapping only (p = 0.01). No between-group difference in massage only and string wrapping only. No within-group differences reported.	N/A	N/A	N/A

ADL activities of daily living, AROM Active range of motion, COPM Canadian Occupational Performance Measure, CT controlled trial, KTAPING Kinesiotaping, MEM Modified manual edema mobilization, MLD Manual lymphatic drainage, N/A Not available, NRS Numeric rating scale, QBA Questionnaire for bilateral activities, RCT Randomized controlled trial, ROM Range of motion, VAS Visual analog scale.

Table 4
Summary of the effects of manual lymphatic drainage on edema, pain, range of motion and patients' function and satisfaction presented per included study and associated quality of evidence.

First author, Year Country Study design	Effect	Edema	Pain	ROM	Function & Satisfaction	Quality Interpretation
Tornatore et al., 2020 Italy RCT	BTWN	+	–	=	N/A	Moderate
	W/IN	N/A	N/A	N/A	N/A	
Pichonnaz et al., 2016 Switzerland RCT	BTWN	=	=	+	=	**Strong**
	W/IN	N/A	+	+	N/A	
Ebert et al., 2013 Australia RCT	BTWN	=	=	+	=	**Strong**
	W/IN	=	=	=	=	
Cavarec et al., 2012 France Crossover CT	BTWN	=	=	N/A	N/A	**Weak**
	W/IN	+	+	N/A	N/A	
Knygsand-Roenhoej & Maribo, 2011 Denmark RCT	BTWN	=	=	=	=	**Strong**
	W/IN	+	+	+	+ N/A	
Härén &Wiberg, 2006 Sweden RCT	BTWN	+	N/A	N/A	N/A	**Strong**
	W/IN	+	N/A	N/A	N/A	
Härén et al., 1999 Sweden Prospective study	BTWN	+	N/A	N/A	N/A	**Moderate**
	W/IN	N/A	N/A	N/A	N/A	
Flowers, 1988 United States crossover RCT	BTWN	– =	N/A	N/A	N/A	**Weak**
	W/IN	N/A	N/A	N/A	N/A	

BTWN Between groups, CT Controlled trial, N/A Not available, RCT Randomized controlled trial, ROM Range of motion W/in Within group.

group (MLD alone) when compared to the control group (placebo composed by a tape-recorded relaxation session) was also reported by Pichonnaz et al. [29]. The other two remaining studies [22,25] did not show a greater effect of the experimental intervention (i.e. MLD alone or combined to other treatment modalities) when compared to the control intervention (standard care in the form of physical therapy, cryotherapy) on ROM.

When looking only at the effect of pre-versus post-MLD treatment (alone or combined to other treatment modalities) on ROM (i.e. within-group effect), only two studies reported results. Ebert et al. [30] reported a significant improvement in active knee extension and flexion over time after total knee arthroplasty after MLD treatment and Knygsand-Roenhoej & Maribo [22] reported a significant increase in active motion of the wrist after distal radius fracture at six weeks in the experimental group (modified manual edema mobilization, a form of MLD). None of the other studies reported results regarding within-group effects.

3.8. Function and satisfaction

Only three studies out of eight reported data related to participants' function and satisfaction. Pichonnaz et al. [29] measured gait parameters and reported no difference between the experimental group (MLD alone) and the control group in gait up to 3 months post-total knee arthroplasty. Ebert et al. [30] reported no significant difference between groups on each subscale of the KOOS in patients having sustained a total knee arthroplasty. However, this study reported significant improvements pre versus post-MLD treatment combined with standard care in the form of physical therapy for the following KOOS subscales: pain, symptoms, activities of daily living, sports and recreation and quality of life [30]. Lastly, Knygsand-Roenhoej & Maribo [22] reported improvement in overall activities of daily living in participants having sustained a distal radius fracture three weeks after inclusion that was significantly greater in the MLD group when compared to the control group.

4. Discussion

We conducted a systematic review aiming to look at the effects of MLD as a treatment modality on clinical presentation (edema, pain, ROM, function and satisfaction) in the context of musculoskeletal injuries. Finding of our review suggest that MLD, used alone or in combination with other treatment modalities, may positively contribute to the management of such injuries. Indeed, when compared to other treatment modalities such as standard care, MLD was reported to be more efficient for edema reduction (5 out of 8 studies, 62.5%) and for ROM improvements (2 out of 4 studies, 50%). The effect of MLD was less obvious for pain management (1 out of 5 studies, 20%) and for improving patients' function (1 study out of 3, 33%).

Findings of our review support the use of MLD for decreasing edema in the context of musculoskeletal injuries. In one study, MLD treatment alone was more efficient than standard care [25] but in four of them, MLD treatment when combined to other type of treatment modalities such as kinesiotaping [25], string wrapping [26] or when added to standard care [27,28] was more efficient than each of those treatment taken individually. Results of our work support the findings of previously published systematic reviews assessing the effect of MLD treatment on edema but in the context of other health conditions. For example, a systematic review examining breast cancer-related lymphedema and including 17 original studies (n = 869 patients) [14] reported that MLD had a significant effect on volume reduction. Thirteen of them (76%) reported results supporting the use of MLD alone or combined being as efficient as other treatments, and among those studies, eight showed that the combination of MLD with other treatment modalities, such as a compression bandaging or an exercise program, was more effective than the use of each treatment taken individually. Another systematic review studying the effect of MLD on lymphedema and including 27 original studies, 14 review articles and 2 consensus articles concluded that the use of complex decongestive treatment (CDT), which is roughly the combination of MLD and bandaging, was effective in reducing lymphedema volume [32]. In addition, the systematic review of Doubblestein and colleagues on the addition of MLD to conventional rehabilitation in people with conditions affecting the musculoskeletal system [15] also demonstrated that MLD alone or combined to a conventional treatment protocol was more efficient in reducing edema when compared to the conventional treatment alone. Finally, four of our included studies that examined edema (50%) also evaluated within-group effects and all of them reported reduction in edema as a result of the treatment. Overall, these results suggest that MLD is an efficient treatment modality in the management of edema post-musculoskelatal injuries.

Our results and those of previous studies are likely explained by the physiological effect of MLD. Properly executed MLD accelerates the rhythm of the lymph flow [8]. The soft tension applied to the tissues opens lymph vessels, enabling them to collect interstitial liquid responsible for edema [8]. This influx increases the lymphatic transport capacity, which will result in a decrease in the volume of the affected region, and thus a decrease in edema [33,34]. It should also be considered that the combination of the MLD with the standard treatment and/or compression bandages seems more effective than the MLD alone. It may be hypothesized that the combination of different treatment modalities aiming to reduce edema would be more effective because of added effects of individual interventions.

Findings of our review moderately support the use of MLD for decreasing pain. Indeed, only one out of five studies reporting data on pain found a significant decrease in pain when MLD treatment was combined with kinesiotaping [25]. The other four studies did not report a significant difference between the use of MLD and that of standard care but still reported a significant reduction in pain pre versus post-MLD treatment [22,29–31]. Therefore, the use of MLD may not be more effective than other treatment modalities but seems to be just as effective as them. Our results support those of a previously published systematic review assessing the effect of MLD on breast cancer-related lymphedema [33]. All studies were randomized or quasi-randomized control trials and four studies out of the six included in the review measured suggestive sensations such as pain. This review reported results suggesting that MLD is as efficient as standard care in decreasing such sensations [33]. Another large systematic review (44 studies included) investigating different conservative treatments for lymphedema included six studies that collected data on pain and heaviness. Findings from those studies suggest that patients receiving MLD in addition to compression bandaging experienced less pain than those receiving only bandaging [35]. These results may be explained by various pain mechanisms. For instance, pain relief can be obtained with MLD based on the gate control theory of pain [36] where appropriate manual pressure and stretching and releasing of the skin will constantly stimulate large diameter sensory fibers which lead to the inhibition of pain messages [36]. MLD which aims to lead to edema reduction also decreases pressure on pain receptors. Once that pressure is alleviated, the transmission of the pain signals is decreased [8].

Findings of our review suggest that the use of MLD could improve ROM in the context of musculoskeletal injuries. Among the four studies reporting data on ROM, two are in favor of MLD use [29,30] and two showed no significant difference between MLD treatment and other treatment modalities [22,25]. Only two of them reported within-group effects, both showing improvement in ROM pre-versus post-MLD treatment [22,30]. The systematic review of Ezzo et al. on the effect of MLD on breast cancer-related lymphedema [33] reported similar results. Among the six studies included in their review, only two reported data on ROM, neither of them showing between group differences. However, one of the study reported a significant improvement in ROM pre-versus post-MLD treatment, suggesting that MLD is as efficient as standard therapy for ROM improvement [33]. The effect of MLD on ROM can be explained by the fact that, by increasing the lymph transportation, MLD accelerates the process of reducing the edema. By reducing edema, the pressure it creates on the tissues will decrease which will enable more movement at the injury site [8].

Finally, findings of our review moderately support the use of MLD for improving patients' function. Three studies [22,29,30] reported no significant difference in function between MLD treatments and standard care (physical therapy). Ebert et al. [30] reported a significant increase in patients' function and satisfaction pre-versus post-MLD treatment when combined to standard care in the form of physical therapy and

Knygsand-Roenhoej and Maribo [22] reported a significant improvement in function in overall activities of daily living pre-versus post-MLD when combined to home exercises. The systematic review on breast cancer-related lymphedema lead by Thompson et al. [14] reported positive results of MLD on quality of life. By reducing the volume of edema, the studied population was more prone to move around, which translated into greater satisfaction. These improvements in function and satisfaction associated with the use of MLD may be explained by the combination of a decrease in pain and an increase in ROM obtained with the treatment. Results obtained through this systematic review corroborate that hypothesis; reporting positive outcomes in decreasing pain and improving ROM [22,29,30]. Less pain and more liberty of motion might facilitate activities of daily living and therefore, increase patients' satisfaction.

Our systematic review has several strength that should be underlined. A rigorous methodology was used to guide the systematic review process, studies investigating the effect of MLD alone or combined to other treatment modalities, as well as articles published in different languages were included (English and French). Seven countries from three continents were represented in the included studies. It was, however, not possible to conduct a meta-analysis due to the significant heterogeneity of the intervention used in the included studies (treatment ranging from 5 min to 45 min, from one treatment to three treatments a week, varying between different techniques such as Vodder, retrograde massage or MEM, and being used alone or combined to kinesiotaping, icing, placebo or standard care), and due to the fact that a limited number of studies provided data on some outcomes. Heterogeneity of interventions (in terms of type of therapy, frequency and duration of treatment), also made it difficult to compare the results of included studies and provide clear conclusions and recommendations on the effects of MLD on clinical presentation post-musculosketetal injuries. A final limitation of the study was the inability to discriminate between levels of physical participation of included participants prior to entering a MLD intervention. Participants in our included studies were recruited post-surgery or in outpatients clinics, regardless of physical activity levels, making it impossible to draw conclusions on the added benefits of MLD in the athletic population.

4.1. Clinical perspective

The results of this systematic review support the use of MLD in the context of musculoskeletal injuries, including post-surgery, and suggest that MLD is a treatment modality that is as effective as other methods, especially to reduce edema. From a clinical standpoint, this technique does not require much equipment, is painless and is financially accessible. A specialized therapist will therefore be able to treat his or her patients in a wide variety of environments, even at the patients' home. It is therefore an interesting treatment alternative when access to other treatment modalities, such as cryotherapy or ultrasound, are uncomfortable or restricted or when the patient has difficulty moving around or leaving the house.

5. Conclusion

The objective of this study was to conduct a systematic review of the literature in order to find out whether the use of MLD in the context of the management of musculoskeletal injuries is more effective than other therapeutic approaches in reducing edema and improving clinical presentation. Based on our work, we were unable to give a clear answer to our research question because of a lack of evidence. However, seven out of the eight studies included in our review reported a positive between or within groups effect of MLD on edema reduction, which is the main goal of this treatment. Therefore, the use of MLD seems to be as effective as other treatment modalities on edema management and seems to be even more effective when combined to the standard care or other treatment modalities such as compressive bandaging.

Since the evidence resulting from this systematic review tends to point that MLD affects the process of reducing edema, a future question to investigate would be whether the effect of such treatment is effective when managing other type of inflammatory response following musculoskeletal injuries such as tendonitis for example.

References

[1] C. Mock, M.N. Cherian, The global burden of musculoskeletal injuries: challenges and solutions, Clin. Orthop. Relat. Res. (2008) 466.
[2] L. March, et al., Burden of disability due to musculoskeletal (MSK) disorders. Best practice & research clinical rheumatology 28 (3) (2014) 353–366.
[3] A. Cieza, et al., Global estimates of the need for rehabilitation based on the global burden of disease study 2019: a systematic analysis for the global burden of disease study 2019, Lancet 396 (10267) (2020) 2006–2017.
[4] S. Lentzkie, S. Stock, Les troubles musculo-squelettiques liés au trval: un fardeau humain et économique évitable, 2019.
[5] Canadian center for occupational health and safety, Available from, https://www.ccohs.ca/topics/hazards/ergonomic/wsmd/#shr-pg-pnl1.
[6] Centers for disease control and prevention: work-related musculoskeletal disorders & ergonomics, Available from, https://www.cdc.gov/workplacehealthpromotion/health-strategies/musculoskeletal-disorders/index.html.
[7] B.J. Hoogenboom, M.L. Voight, W.E. Prentice, Musculoskeletal interventions, techniques for therapeutic exercice, 2014. I. edition, 3 ed.
[8] H. Wittlinger, et al., Dr. Vodder's Manual Lymph Drainage, A Practical Guide, Thieme 143, 2019.
[9] J.P. Villeco, Edema: a silent but important factor, J. Hand Ther. 25 (2) (2012) 153–162.
[10] A. Williams, Manual lymphatic drainage: exploring the history and evidence base, Br. J. Community Nurs. 15 (3) (2013).
[11] P. Hutzschenreuter, U. Herpertz, Primary and secondary lymphedema in children treated with manual lymphdrainage and compression therapy, Eur. J. Lymphol. 14 (14) (1993) 51–57.
[12] A. Finnane, M. Janda, S.C. Hayes, Review of the evidence of lymphedema treatment effect, Am. J. Phys. Med. Rehabil. 94 (6) (2015) 483–498.
[13] C. Lopera, et al., Investigating the short-term effects of manual lymphatic drainage and compression garment therapies on lymphatic function using near-infrared imaging, Lymphatic Res. Biol. 15 (3) (2017) 235–240.
[14] B. Thompson, et al., Manual lymphatic drainage treatment for lymphedema: a systematic review of the literature, J. Canc. Survivorship. 1 (15) (2020).
[15] D. Doubblestein, S. Sublett, M. Huang, Effects of manual lymphatic drainage techniques on conditions affecting the musculoskeletal system: a systematic review, Orthop. Pract. 32 (2) (2020).
[16] D. Moher, et al., Preferred reporting items for systematic review and meta-analysis protocols (prisma-p). 4 (1) (2015).
[17] A. Liberati, et al., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration, J. Clin. Epidemiol. 62 (10) (2009) e1–e34.
[18] B.C. Wallace, et al., Deploying an interactive machine learning system in an evidence-based practice center: abstrackr. (2012) 819–824.
[19] Effective public health practice Project (EPHPP), Quality Assessment Tool for Quantitative Studies (1998).
[20] E.M. Roos, et al., Knee injury and osteoarthritis outcome score (KOOS)—development of a self-administered outcome measure, J. Orthop. Sports Phys. Ther. 28 (2) (1998) 88–96.
[21] L. Engelhart, et al., Validation of the Knee Injury and Osteoarthritis Outcome Score subscales for patients with articular cartilage lesions of the knee, Am. J. Sports Med. 40 (10) (2012) 2264–2272.
[22] K. Knygsand-Roenhoej, T. Maribo, A randomized clinical controlled study comparing the effect of modified manual edema mobilization treatment with traditional edema technique in patients with a fracture of the distal radius, J. Hand Ther: Offc. J. Am. Soc. Hand Ther. 24 (3) (2011) 184–193.
[23] M. Law, et al., The Canadian occupational performance measure: an outcome measure for occupational therapy, Can. J. Occup. Ther. 57 (2) (1990) 82–87.
[24] C.C. Chan, T.M. Lee, Validity of the Canadian occupational performance measure, Occup. Ther. Int. 4 (3) (1997) 231–249.
[25] L. Tornatore, et al., Effects of combining manual lymphatic drainage and Kinesiotaping on pain, edema, and range of motion in patients with total knee replacement: a randomized clinical trial, Int. J. Rehabil. Res. 43 (3) (2020) 240–246 (7).
[26] K.R. Flowers, String wrapping versus massage for reducing digital volume, Phys. Ther. 68 (1) (1988) 57–59.
[27] K. Härén, C. Backman, M. Wiberg, Effect of manual lymph drainage as described by Vodder on oedema of the hand after fracture of the distal radius: a prospective clinical study, Scand. J. Plast. ReConstr. Surg. Hand Surg. 34 (4) (2000) 367–372.
[28] K. Härén, M. Wiberg, A prospective randomized controlled trial of manual lymph drainage (MLD) for the reduction of hand oedema after distal radius fracture, Br. J. Hand Ther. 11 (2) (2006) 41–47.
[29] C. Pichonnaz, et al., Effect of manual lymphatic drainage after total knee arthroplasty: a randomized controlled trial, Arch. Phys. Med. Rehabil. 97 (5) (2016) 674–682.
[30] J.R. Ebert, et al., Randomized trial investigating the efficacy of manual lymphatic drainage to improve early outcome after total knee arthroplasty, Arch. Phys. Med. Rehabil. 94 (11) (2013) 2103–2111.

[31] F. Cavarec, A. Perez, S. Merelle, Effets comparés du drainage lymphatique manuel et de la cryothérapie après arthroplastie prothétique de genou. Kinésithérapie scientifique 535 (2012) 17–23.
[32] B.B. Lasinski, et al., A systematic review of the evidence for complete decongestive therapy in the treatment of lymphedema from 2004 to 2011. PM&R 4 (8) (2012) 580–601.
[33] J. Ezzo, et al., Manual lymphatic drainage for lymphedema following breast cancer treatment, Cochrane Database Syst. Rev. (2015) 5.
[34] B.J. Korosec, Manual lymphatic drainage therapy, Home Health Care Manag. Pract. 16 (6) (2004) 499–511.
[35] M. Oremus, et al., Systematic review: conservative treatments for secondary lymphedema, BMC Canc. 12 (1) (2012) 1–15.
[36] R. Melzack, J. Katz, The gate control theory: reaching for the brain, Pain: Psychol. Perspect. (2004) 13–34.