Hong Kong Journal of Occupational Therapy (2016) 27, 7–17

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.hkjot-online.com

Hong Kong Journal of Occupational Therapy (HKJOT)

REVIEW ARTICLE

Rehabilitation Interventions for Poststroke Hand Oedema: A Systematic Review

Thuy Anh Giang [a,b], Alan Wei Guang Ong [b,c], Karthikeyan Krishnamurthy [b,d,*], Kenneth N.K. Fong [b]

[a] *Department of Rehabilitation (Occupational Therapy), Khoo Teck Puat Hospital, Singapore, Singapore*
[b] *Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China*
[c] *Department of Rehabilitation (Occupational Therapy), SPD, Singapore*
[d] *Hypergiant Occupational Therapy Service and Research Centre, Chennai, Tamil Nadu, India*

Received 28 January 2016; accepted 14 March 2016
Available online 7 June 2016

KEYWORDS
hand oedema;
stroke;
upper extremity;
occupational therapy;
rehabilitation

Summary *Objective/Background:* To review the evidence of rehabilitation interventions for the management of poststroke hand oedema.
Methods: We conducted a systematic review of research articles in electronic databases published in English between 1999 and 2015. Two investigators working independently retrieved articles from the Cochrane Central Register of Controlled Trials, SCOPUS, Taylor & Francis Online, Wiley Online Library, CINAHL, Springer (MetaPress), ScienceDirect, PubMed, SAGE Journals Online, EBSCO, and Web of Science. Only controlled trials with outcome measures and interventions for poststroke hand oedema were included. Three investigators critically appraised the selected studies using the Physiotherapy Evidence Database Scale.
Results: Of the 189 articles identified, nine (5 randomized controlled trials, 3 nonrandomized controlled trials, and 1 crossover controlled trial) were selected. These studies are heterogeneous in terms of design and types of intervention for poststroke hand oedema. The interventions reducing hand oedema are Lycra pressure garments with glove splints, bilateral passive motion upper-limb exercises, laser therapy, and acupressure. However, due to these studies' short intervention periods and the fact that hand oedema is not their primary outcome measure, it is not possible to draw a firm conclusion on their clinical significance for managing poststroke hand oedema.

Funding/support: No funding and financial disclosures were reported by the authors of this paper.
Conflicts of interest: All contributing authors declare that they have no conflicts of interest.
* Corresponding author. Department of Rehabilitation Sciences (Occupational Therapy), The Hong Kong Polytechnic University, Kowloon, Hong Kong, China.
E-mail address: karthik.krishnamurthy@connect.polyu.hk (K. Krishnamurthy).

http://dx.doi.org/10.1016/j.hkjot.2016.03.002

Conclusion: Further study needs to focus solely on interventions for poststroke hand oedema and their long-term effects. No conclusion can be made on the most effective management of poststroke hand oedema until much more evidence is available.

Introduction

Poststroke hand oedema occurs in 37% of individuals who experience a chronic stroke and in up to 18.5% of individuals with acute stroke (Gebruers, Truijen, Engelborghs, & De Deyn, 2011; Leibovitz et al., 2007). Although the exact aetiology of poststroke hand oedema is still inconclusive, a few possible causes have been identified, including sympathetic vasomotor dysfunction and dysregulation of the autonomic nervous system caused by stroke (Artzberger & White, 2011; Hesse, Jahnke, Ehret, & Mauritz, 1995), venous congestion due to immobility, and dependent positioning (Artzberger & White, 2011; Geurts, Visschers, van Limbeek, & Ribbers, 2000). Vascular changes after stroke might also alter the mechanism of filtration and reabsorption of excessive amount of interstitial fluid in the vessels, which may also lead to hand oedema (Wang, Chen, Lan, Wong, & Lai, 2004; Wang, Yang, Liaw, & Wong, 2002). Persistent hand oedema is correlated with pain and fibrosis of the tissue, which have negative effects on hand functions (Boomkamp-Koppen, Visser-Meily, Post, & Prevo, 2005; Geurts et al., 2000). The two most common outcome measures of hand oedema are circumferential measurements and volumetric measurement (Artzberger & White, 2011). The rehabilitation management of poststroke hand oedema includes electrical stimulation (Faghri, 1997; Pandyan, Powell, Futter, Granat, & Stott, 1996), compression therapy (Bell & Muller, 2013; Gustafsson, Walter, Bower, Slaughter, & Hoyle, 2014; Roper, Redford, & Tallis, 1999), orthosis (Bürge et al., 2008; Gracies et al., 2000; Kuppens, Pijlman, Hitters, & van Heugten, 2014), and mobilization (Dirette & Hinojosa, 1994; Giudice, 1990; Kim, Lee, & Sohng, 2014). The effectiveness of contemporary therapies, such as laser therapy and acupressure, for poststroke hand oedema have also been investigated (Kang, Sok, & Kang, 2009; Karabegović, Kapidzić-Duraković, & Ljuca, 2009). However, there is no consensus on the most effective rehabilitation intervention, and very few practical guidelines are available to occupational therapists for managing poststroke hand oedema. This systematic review therefore set out to review the evidence relating to rehabilitation interventions to manage poststroke hand oedema.

Methods

Search strategy

This systematic review included articles from 1999 to 2015 found on the following electronic databases/data sources: the Cochrane Central Register of Controlled Trials, OneSearch—a central electronic search engine covering 10 databases including SCOPUS (Elsevier API), Taylor & Francis Online, Wiley Online Library, CINAHL, Springer (MetaPress), ScienceDirect, PubMed, SAGE Journals Online, EBSCO, and Web of Science. The titles and abstracts of the articles among the search results were assessed for relevance by two independent investigators. Additional search methods included using Google Scholar and manually searching the reference lists of full copies of all relevant articles identified. The keywords used were *stroke*, *hand oedema*, and *hand swelling*.

Selection criteria

Strict inclusion criteria were applied as follows. Only controlled trial studies (i.e., randomized controlled trials [RCTs], non-RCTs, crossover controlled trials) whose full text was available and published in English, and which included outcome measures for poststroke hand oedema and interventions to manage it were included in this review. The study population included adults at all stages of stroke. Studies on the prevalence, aetiology, and assessment of poststroke hand oedema and systematic reviews were excluded.

Assessment of methodological quality

The selected studies were classified based on the Oxford Centre for Evidence-Based Medicine level of evidence (Oxford Centre for Evidence-Based Medicine, 2009). The methodological quality of studies was further appraised by three investigators using the Physiotherapy Evidence Database (PEDro) scale (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). Studies with scores of 6 and above were classified as *high quality*, whereas scores of 4 and 5 were classified as *fair quality*, and scores below 3 were considered *poor quality* (McGill, 2015).

Results

Study selection

The initial search strategy identified 189 articles on the Cochrane Central Register of Controlled Trials ($n = 21$), OneSearch ($n = 166$), Google Scholar ($n = 1$), and by manual search ($n = 1$). Two independent researchers reviewed the titles and abstracts of these articles and excluded 180. The main reasons for exclusion were that the studies focused on the prevalence, aetiology, and assessment of poststroke hand oedema; were duplicates; or were not relevant to the management of poststroke hand oedema. Both reviewers agreed that nine of the articles satisfied the criteria and were suitable for full review. A Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram showing details of the search process can be found in Figure 1.

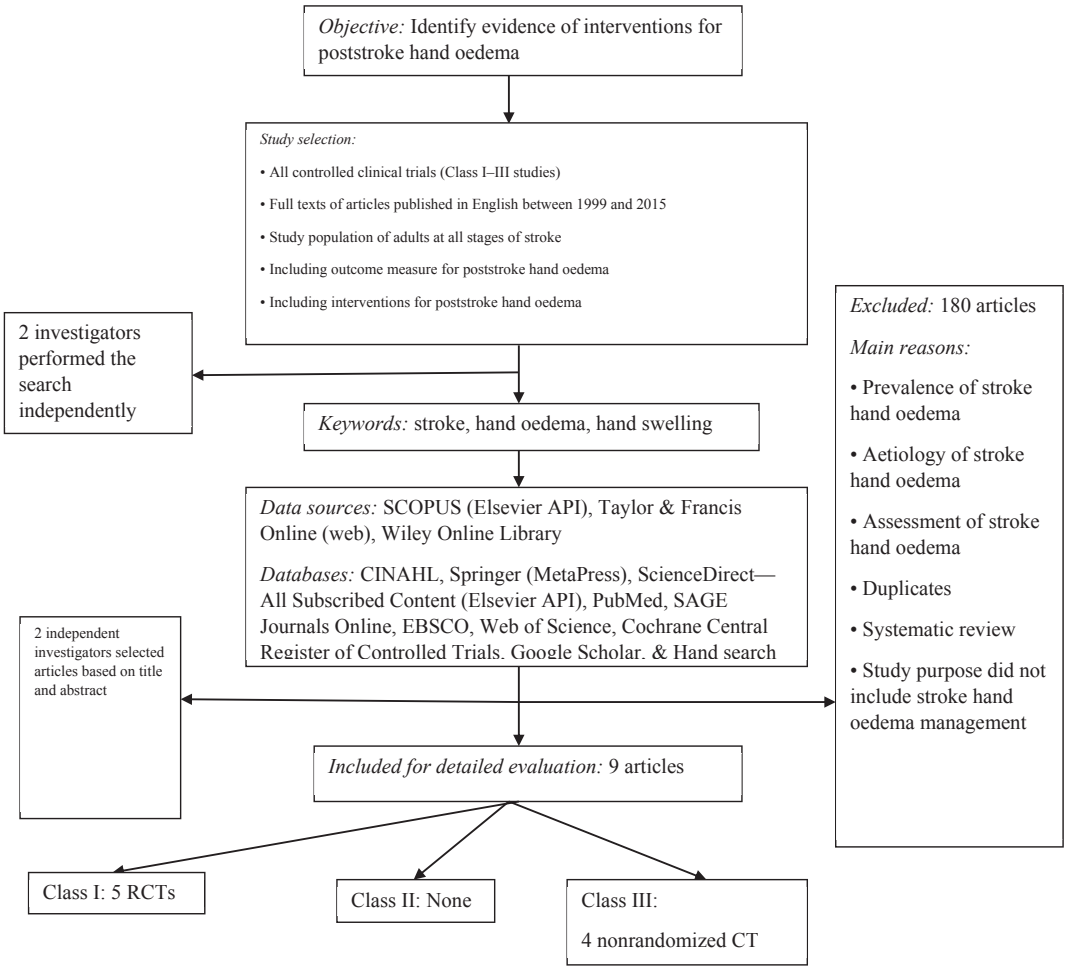

Figure 1 Flowchart of evidence search. *Note*. CT = controlled trial; RCT = randomized controlled trial.

Characteristics

Nine studies were selected for systematic review (Bell & Muller, 2013; Bürge et al., 2008; Gracies et al., 2000; Gustafsson et al., 2014; Kang et al., 2009; Karabegović et al., 2009; Kim et al., 2014; Kuppens et al., 2014; Roper et al., 1999). Of these nine studies, five were Class I RCTs (Bell & Muller, 2013; Bürge et al.; Kang et al.; Kim et al.; Roper et al.) and four were Class III (3 non-RCTs [Gustafsson et al.; Karabegović et al.; Kuppens et al.] and 1 crossover controlled trial [Gracies et al.]). Four studies were good-quality controlled trials (Bell & Muller, 2013; Bürge et al.; Kang et al.; Kim et al.) and five were fair-quality controlled trials (Gracies et al.; Gustafsson et al.; Karabegović et al.; Kuppens et al.; Roper et al.), according to the PEDro scale (Table 1).

The studies compiled in this review represented 424 participants, with samples ranging from eight to 206 participants. The mean age of participants ranged from 55.2 years to 74.5 years. One study recruited patients in the acute stage of stroke (Kim et al., 2014); four recruited participants at the subacute stage of stroke (Bell & Muller, 2013; Bürge et al., 2008; Gustafsson et al., 2014; Roper et al., 1999); one recruited participants with both subacute and chronic stroke (Kang et al., 2009); and two studies did not state the stage of their participants (Karabegović et al., 2009; Kuppens et al., 2014). The time poststroke ranged from within 72 hours to 56 weeks (Table 2).

The outcome measures used for poststroke hand oedema were circumferential measurements using a measuring tape or jeweller's ring measurement device and measuring hand volume using a volumeter. The upper-limb sites used for circumferential measurements were the metacarpophalangeal joints (MCPJs) and the wrist joint (Bell & Muller, 2013); the proximal phalange of the index finger, the mid-metacarpal line, and the wrist joint (Bürge et al., 2008); the second phalanx of the middle finger, mid-forearm, and mid-arm (Gracies et al., 2000); the proximal phalanx of the middle finger, the MCPJs, the wrist joint, and mid-forearm (Gustafsson et al., 2014); the base of the index finger (Kang et al., 2009); the dorsum of the hand (Karabegović et al., 2009); the index finger, wrist, and elbow (Kim et al., 2014). Hand volume was evaluated by a volumeter, which measures the amount of water displaced by the hand (Kuppens et al., 2014; Roper et al., 1999; Table 3).

Table 1 PEDro Scale.

PEDro scale items	Bell & Muller (2013)	Bürge et al. (2008)	Gracies et al. (2000)	Gustafsson et al. (2014)	Kang, Sok, & Kang (2009)	Karabegović, Kapidzić-Duraković, & Ljuca (2009)	Kim, Lee, & Sohng (2014)	Kuppens, Pijlman, Hitters, & van Heugten (2014)	Roper, Redford, & Tallis (1999)
Eligibility	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1. Random allocation	1	1	0	0	1	0	1	0	1
2. Concealed allocation	0	1	0	0	0	0	0	0	0
3. Baseline comparability	1	1	1	1	1	1	1	1	1
4. Blind participants	0	0	0	0	1	0	0	0	0
5. Blind therapists	0	0	0	0	0	0	1	0	0
6. Blind assessors	1	0	0	0	1	0	1	0	1
7. Adequate follow-up	0	1	1	1	1	1	1	1	1
8. Intention-to-treat analysis	1	1	1	1	1	1	1	1	0
9. Between-group statistical comparisons	1	1	1	1	1	1	1	1	1
10. Point estimates & measures of variability	1	0	0	0	0	1	1	1	0
Total score	6	6	4	4	7	5	8	5	5
RCT quality	High	High	Fair	Fair	High	Fair	High	Fair	Fair

0 = No; 1 = Yes.
Note. PEDro = Physiotherapy Evidence Database Scale; RCT = randomized controlled trial.

Interventions for poststroke hand oedema

Compression therapy

Two RCTs and one crossover controlled trial investigated the effect of compression therapy on the management of poststroke hand oedema (Bell & Muller, 2013; Roper et al., 1999). In Roper et al., patients randomly assigned to an experimental group were treated with an intermittent pneumatic compression machine, which applied 50 mmHg of pressure to the hemiplegic limb for a 30-second inflation and 20-second deflation duty cycle. Participants went through two 2-hour sessions per day for 1 month. The treatment regimen was determined following a pilot study. Both experimental and control groups still received standard physiotherapy, but not modalities that might affect hand oedema. The primary outcome measure was hand volume, which was taken at the same time every day and after the patients had rested for 30 minutes after treatment to prevent errors due to change in hand volume during the course of the 24-hour cycle. The results showed that there was no significant change in hand volume before and after treatment, or between the two groups. There was also no significant change between the experimental and control groups. The study was rated as fair quality with a PEDro score of 5/10.

In a more recent study, Bell and Muller (2013) evaluated the use of kinesio tape on poststroke hand oedema. In the experimental group, kinesio tape was applied to the participants' hemiplegic upper limb for 6 days. Using a buttonhole technique, the kinesio tape was applied from the dorsal to the volar side of the affected hand with 20% stretch on each side, covering two thirds of the forearm with 10% stretch. Both experimental and control groups received standard therapy. The primary outcome measure was circumferential measurements of the MCPJs and the wrist joint using a measuring tape. The result did not show a statistically significant reduction in hand oedema between the two groups. Medium and large reduction of hand oedema was seen at the MCPJs and the wrist joint in the experimental group. The study was rated as high quality with a score of 6/10 on the PEDro scale.

The efficacy of high- and low-stretched compression bandages was investigated by Gustafsson et al. (2014) in a repeated-measure crossover single-case study with eight participants. The main outcome measure was circumferential measurement at the proximal phalanx of the middle finger, the MCPJs, the wrist joint, and the mid-forearm. Circumferential compression bandaging was applied spirally along the length of the fingers, covering the dorsal and palmar sides of the affected

Table 2 Characteristics of the Participants Recruited to Each Study.

Authors	Diagnosis	No. of participants (*N*) Age (y), mean ± SD (range)	Sex	Side of hemiparesis	Severity of hemiparesis	Time since stroke
Bell & Muller (2013)	Stroke	Total participants *N* = 17 Experimental group: *n* = 9 Age: 67.2 ± 13.0 y Control group: *n* = 8 Age: 64.0 ± 13.5 y	Experimental group: Male: 4 Female: 5 Control group: Male: 5 Female: 3	Experimental group: Left: 4 Right: 5 Control group: Left: 6 Right: 2	Experimental group: pre-FMA median ± SD (range): 9 ± 16.9 (4—58) Control group: pre-FMA median ± SD: 14.5 ± 22.0 (5—53)	Experimental group: mean ± SD (range) 18 ± 22.3 d (5—57 d) Control group: mean ± SD (range) 14 ± 9.1 d (7—31 d)
Bürge et al. (2008)	Stroke	Total participants *N* = 30 Experimental group: *n* = 15 Age: 68 ± 12 y Control group: *n* = 15 Age: 64 ± 14 y	Experimental group: Male: 6 Female: 9 Control group: Male: 5 Female: 10	Experimental group: Left: 10 Right: 5 Control group: Left: 8 Right: 7	Experimental group: pre-FMA median ± SD: 9 (0—30) Control group: pre-FMA median ± SD: 11 (0—45)	Experimental group mean ± SD (range) 29 ± 15.7 d (15—74 d) Control group: mean ± SD (range) 30 ± 12.1 d (12—57 d)
Gracies et al. (2000)	Hemiplegia	Total participants *N* = 16 Age: 65 ± 4 y	Male: 11 Female: 5	Left: 7 Right: 9	Not available	Participants: 21—117 d
Gustafsson et al. (2014)	Stroke	Total participants *N* = 8	Not available	Left: 5 Right: 3	Not available	Not available
Kang, Sok, & Kang (2009)	Stroke	Total participants *N* = 56 Experimental group: *n* = 28 Age: 50—71 y Control group: *n* = 28 Age: 50—71 y	Experimental group: Male: 14 Female: 14 Control group: Male: 17 Female: 11	Experimental group: Left: 15 Right: 13 Control group: Left: 17 Right: 11	Not available	Experimental group: 14—56 wk Control group: 14—56 wk
Karabegović, Kapidzić-Duraković, & Ljuca (2009)	Stroke	Total participants *N* = 70 Age: 63.4 ± 8.8 y Experimental group: *n* = 35 Control group: *n* = 35	Not available	Not available	Not available	Not available
Kim, Lee, & Sohng (2014)	Acute stroke	Total participants *N* = 37 Experimental group: *n* = 19 Age: 59.2 ± 14.1 y Control group: *n* = 18 Age: 63.0 ± 16.2 y	Experimental group: Male: 14 Female: 5 Control group: Male: 8 Female: 10	Experimental group: Left: 10 Right: 9 Control group: Left: 9 Right: 9	Experimental group: Brunnstrom recovery stage mean ± SD: 1.1 ± 10.6 Control group: Brunnstrom recovery stage mean ± SD: 1.3 ± 5.7	Experimental group: acute stroke within previous 72 h Control group: acute stroke within previous 72 h

(*continued on next page*)

Table 2 (*continued*)

Authors	Diagnosis	No. of participants (*N*) Age (y), mean ± SD (range)	Sex	Side of hemiparesis	Severity of hemiparesis	Time since stroke
Kuppens, Pijlman, Hitters, & van Heugten (2014)	Stroke	Total participants *N* = 206 Experimental group: *n* = 129 Age: 60.1 ± 9.5 y Control group: *n* = 77 Age: 55.2 ± 11.5 y	Experimental group: Male: 82 Female: 47 Control group: Male: 53 Female: 24	Experimental group: Left: 74 Right: 55 Control group: Left: 40 Right: 37	Experimental group: Utrecht arm/hand test mean ± SD: 3.57 ± 3.04 Control group: Utrecht arm/hand test mean ± SD: 5.18 ± 2.77	Not available
Roper, Redford, & Tallis (1999)	Stroke	Total participants *N* = 37 Experimental group: *n* = 20 Age: 74.5 y Control group: *n* = 17 Age: 72.0 y	Experimental group: Male: 8 Female: 12 Control group: Male: 8 Female: 9	Experimental group: Left: 9 Right: 11 Control group: Left: 8 Right: 9	Experimental group: Motricity Index median (interquartile range): 5 (39) Control group: Motricity Index median (interquartile range): 0 (16)	Experimental group: 3.5 wk Control group: 6.0 wk

Note. FMA = Fugl–Meyer Assessment; SD = standard deviation.

hand with 50% overlap. The low-stretched group received Handy Gauze Cohesive bandages and the high-stretched group received Coban bandages. Outcome measures were taken three times, before, during, and after intervention, for each group. The results showed reduction in hand oedema in both groups but only during the 1-week intervention phase. Hand oedema was noted to increase after the intervention. No significant difference between the high- and low-stretched groups was identified. This study was rated as fair quality with a PEDro score of 4/10.

Orthosis

Three studies investigated the effects of orthosis on poststroke hand oedema. The first was an RCT (Bürge et al., 2008); the second was a single-subject crossover trial (Gracies et al., 2000); and the third was a nonrandomized comparative trial (Kuppens et al., 2014).

The participants in the experimental group of the RCT study by Bürge et al. (2008) wore a neutral functional realignment orthosis for at least 6 hours daily in addition to undergoing the standard 13-week rehabilitation programme. The control group only received the standard rehabilitation. The orthosis was designed to allow the use of the hand and fingers to manipulate objects while providing support to the carpal arches and wrist in a neutral position. The outcome measure for hand oedema was circumferential measurement using a tape. The results showed that a neutral functional realignment orthosis had no effects on subacute poststroke hand oedema. This study was rated as a high-quality RCT with a PEDro score of 6/10.

In the single-subject crossover trial study by Gracies et al. (2000), the participants wore a Lycra garment in addition to a glove splint for 3 hours on Day 1. On Day 2, they wore neither. The arm garment consisted of a series of circumferential Lycra segments sewn together from the top to the bottom of a sleeve. Depending on the chosen direction of pull, the segments were oriented appropriately and then stretched. The custom-fitted glove splint, made of Lycra, was designed with two semiflexible plastic sticks which extended from mid-forearm on the palmar aspect to the palm of the hand. The outcome measure for hand oedema was circumferential measurement using a tape. The results showed that wearing the Lycra garment for 3 hours produced statistically significant reduction in the swelling of the affected upper limb. This study was rated as fair in quality with a PEDro score of 4/10.

The participants in the experimental group of the nonrandomized comparative trial by Kuppens et al. (2014) received a treatment protocol that included the use of hand realignment orthosis. Based on the protocol, the experimental group used the orthosis at night initially. When there was no improvement in the oedema, participants needed to undergo other forms of intervention, such as cryotherapy and compression tape in addition to the hand orthosis. The control group received nonstandardized usual care. The hand realignment orthosis was not described in the study. The outcome measure of hand oedema was hand

Table 3 Summary of Studies Investigating the Use of Different Interventions for Poststroke Hand Oedema.

Authors	Study design (*n*)	Intervention groups	Treatment regimen	Length of study	Outcome measure for hand oedema	Results
Bell & Muller (2013)	RCT $n = 17$	Experimental group: Kinesio tape applied to the hand & forearm & received standard therapy. Control group: received standard therapy.	Kinesio tape was applied within 30 min of initial assessment & kept on for 6 d.	6 d	Circumferential measurements using a measuring tape at the metacarpophalangeal joints (MCPJs) & the wrist joint.	No significant difference in the reduction of oedema between the 2 groups at the wrist ($p = .189$) or the MCP ($p = .111$). Medium & large effects in reduction of hand oedema were seen at the MCPJs & wrist joint in the experimental group.
Bürge et al. (2008)	RCT $n = 30$	Experimental group: received neutral functional realignment orthosis & standard care. Control group: standard care.	Neutral functional realignment orthosis was worn for at least 6 h daily for 13 wk.	13 wk	Circumferential measurements using a measuring tape at the proximal phalange of the index finger, the mid-metacarpal line, & the wrist joint.	No significant difference in reduction of hand oedema between the 2 groups ($p = .481$). Preintervention: only 1 participant in each group had hand oedema. Postintervention: 1 participant in the experimental group & 2 participants in the control group had hand oedema.
Gracies et al. (2000)	Single-group crossover design $n = 16$	Participants spent periods wearing a customized dynamic Lycra garment together with a glove splint & not wearing them.	The Lycra garment & glove splint were worn for 3 h for 1 d only.	2 d	Circumferential measurements using a measuring tape at the second phalanx of the middle finger, at the mid-forearm, & the mid-arm.	Significant difference in reduction of oedema at the middle finger ($p = .012$) & forearm ($p = .049$) between the group wearing dynamic Lycra splint & the group without.
Gustafsson et al. (2014)	Single-case study—ABA design $n = 8$	Participants were alternately assigned to receive low- or high-stretch bandaging.	1 wk for each group (either high- or low-stretch bandaging).	17 d	Circumferential measurements using a measuring tape at the proximal phalanx of the middle finger, the MCPJs, the wrist joint, & the mid-forearm.	Reduction in hand oedema was noted in both groups during intervention only. No reduction in hand oedema postintervention. No significant difference between the 2 groups.

(*continued on next page*)

Table 3 (*continued*)

Authors	Study design (*n*)	Intervention groups	Treatment regimen	Length of study	Outcome measure for hand oedema	Results
Kang, Sok, & Kang (2009)	RCT $n = 56$	Experimental group: received meridian acupressure in addition to general physical therapy. Control group: received routine care only.	Meridian acupressure after general physical therapy for 10 min/d over 2 wk.	2 wk	Circumferential measurement at the base of the index finger using jeweller's ring measurement device.	Significant difference in the reduction of oedema in fingers between the 2 groups ($p < .001$).
Karabegović, Kapidzić-Duraković, & Ljuca (2009)	Quasi-experimental design $n = 70$	Experimental group: received laser to points that are painful in the shoulder & swollen area on the dorsum of the hand. Also received kinesis therapy & ice massage. Control group: received transcutaneous electrical nerve stimulation & stable galvanization in addition to kinesis therapy & ice massage.	Intervention was carried out every working day for the first 3 wk, then 3 times a wk in the 4^{th} wk & 5th wk. In the last wk, the intervention was only carried out 2 times.	6 wk	Circumferential measurements of oedema on the dorsum of the hand using a centimetre band.	Significant difference in the reduction of oedema in fingers between the 2 groups ($p = .001$).
Kim, Lee, & Sohng (2014)	RCT $n = 37$	Experimental group: received bilateral passive range of upper-limb motion exercises after pretest. Control group: received the same treatment protocol as the experimental group 2 wk after the pretest.	Bilateral passive range of motion exercise was performed 2 times daily (once in the morning & once in the evening) for 4 wk.	4 wk	Circumferential measurements using a measuring tape at the index finger, wrist, & elbow on both upper limbs.	Significant differences in the reduction of oedema in the fingers, wrist, & elbow of affected upper limbs between the 2 groups at 2 wk & 4 wk postintervention ($p < .05$). Significant reduction of oedema in the unaffected upper limbs in both groups ($p = .001$) but no significant difference between the 2 groups.

Table 3 (*continued*)

Authors	Study design (*n*)	Intervention groups	Treatment regimen	Length of study	Outcome measure for hand oedema	Results
Kuppens, Pijlman, Hitters, & van Heugten (2014)	Prospective nonrandomized comparative design. $n = 206$	Experimental group: received Blixembosch hand oedema protocol. Control group: usual care.	Intervention consisted of preventive measures as well as possible treatment regimen consisting of the following: • Hand orthosis • Orthosis & cryotherapy • Orthosis, cryotherapy, & compression tape • Orthosis, cryotherapy, compression tape, & lymphatic drainage • Orthosis & elastic glove The treatment regimen varied from participant to participant.	On average, around 3 mo	Hand volume using a volumeter.	16% of participants in the intervention group, compared with 21% in the control group, developed hand oedema postadmission. The result was significant ($p = .019$). This result demonstrates the small positive effect of the intervention protocol on hand oedema compared with usual care.
Roper, Redford, & Tallis (1999)	RCT $n = 37$	Experimental group: intermittent pneumatic compression with standard physiotherapy. Control group: standard physiotherapy only.	2 2-h sessions of intermittent pneumatic compression/d for 1 mo.	4 wk	Hand volume using a volumeter.	No significant difference in the reduction of hand oedema between the 2 groups. No significant reduction of hand oedema in the experimental group postintervention ($p > .99$).

Note. RCT = randomized controlled trial.

volume measurement using a volumeter. The results showed that the protocol that included the use of a hand orthosis had small beneficial effects on poststroke hand oedema. This study was rated as fair quality with a PEDro score of 5/10.

Mobilization

The RCT by Kim et al. (2014) investigated the effects of mobilization on poststroke hand oedema. Their experimental group engaged in bilateral passive range of motion (ROM) exercises once in the morning and once in the evening for 5 days a week over a period of 4 weeks. Each intervention session lasted for 15 minutes and each move of the exercise routine was made 10 times. The unaffected upper extremity was exercised first, before the affected side. The routine consisted of shoulder, elbow, wrist, and finger joint exercises. The control group received the same protocol 2 weeks later. The outcome measure of hand oedema was circumferential measurement using a tape. The results showed that there was a significant reduction in oedema of bilateral upper extremities in the experimental group relative to the

control group. This study showed that ROM exercises were effective in reducing postacute stroke oedema. It was rated as high quality with a PEDro score of 8/10.

Contemporary therapies

Laser therapy. A quasi-experimental study by Karabegović et al. (2009) investigated the effect of laser therapy on poststroke hand oedema. In their experimental group, laser therapy was applied to the painful joints in the shoulder and in the area of swelling on the dorsum of the hand in addition to kinesis therapy and ice massage over a 6-week period; the frequency of treatment was reduced gradually. The laser was applied by BTL 2000 with a probe of 50 mW and wavelength of 830 nm. The control group received electrotherapy in addition to kinesis therapy and ice massage. The outcome measure was a centimetre band to measure swelling. The results showed significant reduction of poststroke hand oedema by these combined therapies. This study was rated as fair quality with a PEDro score of 5/10.

Acupressure. An RCT by Kang et al. (2009) investigated the effects of meridian acupressure on poststroke hand oedema. Their experimental group received meridian acupressure for 10 minutes daily after general physical therapy over a 2-week period. The control group received routine care only. Meridian acupressure is a finger acupressure technique pressing on the 14 meridian points in the Qi flow. The outcome measure was a jeweller's ring measurement device. The results showed significant reduction of hand oedema in the experimental group. This study showed that the use of meridian acupressure in addition to general physical therapy is effective in reducing oedema in the joints; it is also an economical intervention. This study was rated as high quality with a PEDro score of 7/10.

Discussion

Effectiveness of interventions for management of poststroke hand oedema

The interventions that show significant treatment effect in reducing poststroke hand oedema are the Lycra garment with glove splint, bilateral passive range of upper-limb motion exercises, laser therapy, and acupressure. However, because the intervention period for the Lycra garment with glove splint was only 3 hours, the significance of the study may not be translatable into clinical practice due to its small changes (Gracies et al., 2000). The ROM exercises were effective in reducing poststroke hand oedema in patients with acute stroke within the previous 72 hours, and the results might not be generalized to subacute or chronic stroke (Kim et al., 2014). The specific effect of laser therapy in reducing hand oedema remains unknown as laser therapy was not the primary treatment involved (Karabegović et al., 2009).

The interventions demonstrating nonsignificant treatment effect are bandaging, intermittent compression, kinesio tape, neutral functional realignment orthosis, and hand realignment orthosis. The nonsignificant effect of intermittent compression on hand oedema might be due to inadequate treatment parameters or the fact that the patients did not receive the full treatment regimen (Roper et al., 1999). The insignificant result for neutral functional realignment orthosis may be due to the fact that only two of the 30 patients in the study had hand oedema before the intervention (Bürge et al., 2008). Although the hand realignment orthosis study showed small beneficial effects on poststroke hand oedema, the results need to be interpreted with care as the study was not designed to measure only the effectiveness of orthosis. Other interventions in the study besides the orthosis may have contributed to the reduction of hand oedema (Kuppens et al., 2014).

Limitations of the studies chosen

Most of the studies were not double blinded, which may have reduced their quality. Only four of the nine studies investigated hand oedema exclusively (Bell & Muller, 2013; Gustafsson et al., 2014; Kuppens et al., 2014; Roper et al., 1999). As for the other five studies, measurement of hand oedema was just one of the outcome measures (Bürge et al., 2008; Gracies et al., 2000; Kang et al., 2009; Karabegović et al., 2009; Kim et al., 2014). All nine studies investigated only the short-term effects of interventions for poststroke hand oedema. None included follow-up for long-term effects. There is not enough research to argue for the effectiveness of each area of intervention for poststroke hand oedema. The studies' samples were also small, which may lead to bias.

Limitations of the systematic review

One of the limitations is that, due to the diversity of rehabilitation interventions and the limited evidence for each, the findings of this review cannot serve as a clinical guide to the management of poststroke hand oedema in the literature.

Conclusion

Occupational therapists are commonly involved in the management of poststroke hand oedema in hospitals or convalescent institutions. However, no firm conclusion on their clinical effectiveness in managing poststroke hand oedema can be drawn at this stage. More research is needed in this area. Future work should focus solely on interventions for poststroke hand oedema and the long-term outcomes of poststroke hand oedema management. The effectiveness of contemporary interventions such as laser therapy and meridian acupressure on poststroke hand oedema should also be investigated as they show promising results.

References

Artzberger, S. M., & White, J. (2011). Edema control. In G. Gillen (Ed.), *Stroke rehabilitation: A function-based approach* (pp. 307—500). St Louis: Elsevier.

Bell, A., & Muller, M. (2013). Effects of kinesio tape to reduce hand edema in acute stroke. *Topics in Stroke Rehabilitation, 20*(3), 283—288.

Boomkamp-Koppen, H., Visser-Meily, J., Post, M., & Prevo, A. (2005). Poststroke hand swelling and edema: prevalence and relationship with impairment and disability. *Clinical Rehabilitation, 19*(5), 552—559.

Bürge, E., Kupper, D., Finckh, A., Ryerson, S., Schnider, A., & Leemann, B. (2008). Neutral functional realignment orthosis prevents hand pain in patients with subacute stroke: a randomized trial. *Archives of Physical Medicine and Rehabilitation, 89*(10), 1857—1862.

Dirette, D., & Hinojosa, J. (1994). Effects of continuous passive motion on the edematous hands of two persons with flaccid hemiplegia. *The American Journal of Occupational Therapy, 48*(5), 403—409.

Faghri, P. D. (1997). The effects of neuromuscular stimulation-induced muscle contraction versus elevation on hand edema in CVA patients. *Journal of Hand Therapy, 10*(1), 29—34. http://dx.doi.org/10.1016/S0894-1130(97)80008-7.

Gebruers, N., Truijen, S., Engelborghs, S., & De Deyn, P. P. (2011). Incidence of upper limb oedema in patients with acute hemiparetic stroke. *Disability and Rehabilitation, 33*(19—20), 1791—1796.

Geurts, A. C., Visschers, B. A., van Limbeek, J., & Ribbers, G. M. (2000). Systematic review of aetiology and treatment of post-stroke hand oedema and shoulder-hand syndrome. *Scandinavian Journal of Rehabilitation Medicine, 32*(1), 4—10.

Giudice, M. L. (1990). Effects of continuous passive motion and elevation on hand edema. *The American Journal of Occupational Therapy, 44*(10), 914—921. http://dx.doi.org/10.5014/ajot.44.10.914.

Gracies, J. M., Marosszeky, J. E., Renton, R., Sandanam, J., Gandevia, S. C., & Burke, D. (2000). Short-term effects of dynamic Lycra splints on upper limb in hemiplegic patients. *Archives of Physical Medicine and Rehabilitation, 81*(12), 1547—1555.

Gustafsson, L., Walter, A., Bower, K., Slaughter, A., & Hoyle, M. (2014). Single-case design evaluation of compression therapy for edema of the stroke-affected hand. *The American Journal of Occupational Therapy, 68*(2), 203—211.

Hesse, S., Jahnke, M., Ehret, R., & Mauritz, K. (1995). Shoulder-hand syndrome in hemiplegic patients: Temperature, sympathetic skin responses, and nerve latencies of the affected and nonaffected upper extremity. *Neurorehabilitation and Neural Repair, 9*(4), 229—233.

Kang, H. S., Sok, S. R., & Kang, J. S. (2009). Effects of meridian acupressure for stroke patients in Korea. *Journal of Clinical Nursing, 18*(15), 2145—2152.

Karabegović, A., Kapidzić-Duraković, S., & Ljuca, F. (2009). Laser therapy of painful shoulder and shoulder-hand syndrome in treatment of patients after the stroke. *Bosnian Journal of Basic Medical Sciences, 9*(1), 59—65.

Kim, H. J., Lee, Y., & Sohng, K. Y. (2014). Effects of bilateral passive range of motion exercise on the function of upper extremities and activities of daily living in patients with acute stroke. *Journal of Physical Therapy Science, 26*(1), 149—156.

Kuppens, S. P., Pijlman, H. C., Hitters, M. W., & van Heugten, C. M. (2014). Prevention and treatment of hand oedema after stroke. *Disability and Rehabilitation, 36*(11), 900—906.

Leibovitz, A., Baumoehl, Y., Roginsky, Y., Glick, Z., Habot, B., & Segal, R. (2007). Edema of the paretic hand in elderly post-stroke nursing patients. *Archives of Gerontology and Geriatrics, 44*, 37—42. http://dx.doi.org/10.1016/j.archger.2006.02.005.

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical Therapy, 83*(8), 713—721.

McGill. (2015). *Methods*. Retrieved November 23, 2015, from https://www.mcgill.ca/cpengine/methods.

Oxford Centre for Evidence-Based Medicine. (2009). *Levels of evidence*. Retrieved October 1, 2015, from http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence/.

Pandyan, A. D., Powell, J., Futter, C., Granat, M. H., & Stott, D. J. (1996). Effects of electrical stimulation on the wrist of hemiplegic subjects. *Physiotherapy, 82*(3), 184—188.

Roper, T. A., Redford, S., & Tallis, R. C. (1999). Intermittent compression for the treatment of the oedematous hand in hemiplegic stroke: a randomized controlled trial. *Age and Ageing, 28*(1), 9—13.

Wang, J. S., Chen, S. Y., Lan, C., Wong, M. K., & Lai, J. S. (2004). Neuromuscular electric stimulation enhances endothelial vascular control and hemodynamic function in paretic upper extremities of patients with stroke. *Archives of Physical Medicine and Rehabilitation, 85*(7), 1112—1116.

Wang, J. S., Yang, C. F., Liaw, M. Y., & Wong, M. K. (2002). Suppressed cutaneous endothelial vascular control and hemodynamic changes in paretic extremities with edema in the extremities of patients with hemiplegia. *Archives of Physical Medicine and Rehabilitation, 83*(7), 1017—1023.