Journal of Hand Therapy 34 (2021) 3–17

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

JHT Read for Credit Article #730.
Scientific/Clinical Article

Tactile stimulation programs in patients with hand dysesthesia after a peripheral nerve injury: A systematic review

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ARTICLE INFO

Article history:
Received 14 October 2019
Received in revised form
20 March 2020
Accepted 2 May 2020
Available online 19 August 2020

Keywords:
Dysesthesia
Allodynia
Pain
Desensitization
Somatosensory rehabilitation
Hand exercises

ABSTRACT

Study Design: This is a systematic review performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses standards.
Introduction: Diverse approaches based on tactile stimulation are used in hand rehabilitation settings to treat touch-evoked dysesthesias. However, there is a lack of literature synthesis on the description and the effectiveness of the various approaches based on tactile stimulation that can be used for treating hand dysesthesia after nerve injury.
Purpose of the Study: The purpose of the study was to summarize the current evidence on tactile stimulation programs for managing touch-evoked hand dysesthesia due to nerve injury.
Methods: The search was carried out on Medline, Embase, CINAHL, and the Cochrane Library databases. The selected studies had to present patients with touch-evoked dysesthesia after nerve injury who were treated with tactile stimulation approaches to reduce pain. The methodological quality of the included studies was assessed using the methodological index for nonrandomized studies scale, as well as the risk of bias.
Results: Eleven studies met the inclusion criteria. These studies present tactile stimulation interventions that are heterogeneous relative to the target populations and the intervention itself (desensitization versus somatosensory rehabilitation method). Painful symptoms appear to diminish in patients with touch-evoked hand dysesthesia, regardless of the tactile stimulation program used. However, the included studies present significant risks of bias that limit the confidence in these results.
Discussion: The evidence does not unequivocally support the beneficial effects of tactile stimulation to treat touch-evoked hand dysesthesia.
Conclusion: Future studies with more rigorous methodological designs, such as randomized controlled trials, are required to verify the potential benefits of these approaches.

Introduction

Nerve injuries, including neuropathies, are among the top ten diagnoses seen in the field of hand therapy.[1] Focal neuropathies are impairments that affect a single peripheral nerve. In some cases, these neuropathies can affect several branches of peripheral nerves (eg, multiple mononeuropathies). They most often result from a mechanical injury such as compression or trauma.[2] The incidence of focal neuropathies after trauma is estimated at 5%,[3] with 80% of these neuropathies affecting the upper limb.[4] Given the higher incidence of upper limb focal neuropathies, these conditions are frequently encountered in hand rehabilitation.

Conflicts of interest: Two authors (I.Q., T.P.) have given paid presentations that included this topic, and three authors (I.Q., T.P., J.O.D.) are either authors of some of the material included in this review or have other publications with authors of the included studies.

Funding: No author received funding in support of this work.

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https://doi.org/10.1016/j.jht.2020.05.003

The signs and symptoms of neuropathies often include sensory loss, motor weakness, autonomic dysregulation, and neuropathic pain (NP). The latter is defined as "pain caused by a lesion or disease of the somatosensory nervous system."[5] Neuropathic pain from a peripheral nerve injury may affect functional performance and quality of life. Several studies have found a correlation between neuropathic pain intensity and decreased function in patients with peripheral nerve injuries.[6-8] NP can include dysesthesia, which is defined as "an unpleasant abnormal sensation, whether spontaneous or evoked."[5] Allodynia is a clinical term for a specific form of dysesthesia where pain is evoked by normally painless stimuli.[5] In the case of allodynia, pain may be evoked by different types of stimuli, such as cold and heat (thermal allodynia) or light touch on the skin (mechanical allodynia). When mechanical allodynia is present in the hand, it can particularly affect function by causing pain during tasks that require the sense of touch. Allodynia can arise from different causes such as inflammation in acute injuries and nervous system injuries or dysfunction. This paper focuses on allodynia related to peripheral nerve injuries (PNIs) as these conditions are commonly seen in hand therapy settings.

Although a systematic review has already been done on tactile stimulation programs for hand hypoesthesia after PNI,[9] there is currently no literature synthesis describing such programs and their effects on hand dysesthesia. A variety of methods based on tactile stimulation are used to treat dysesthesia. These methods often include programs such as the desensitization method[10-12] and the Somatosensory Rehabilitation Method (SRM), which have been used to treat dysesthesia in different parts of the body.[13] The use of these programs in hand dysesthesia may pose challenges. Program outcomes may differ from those obtained with other body parts because of the specific functional and somatosensory characteristics of the hand. The purpose of this systematic review is to summarize the current evidence on tactile stimulation programs for managing hand dysesthesia due to PNI. This review may prove useful to hand therapists in determining the limits and application of tactile stimulation programs for treating patients with hand dysesthesia arising from PNI. It may also guide hand therapists in determining which tactile stimulation program is most appropriate for their clients.

Methods

This systematic review was planned, performed, and reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The protocol for this systematic review is registered in the PROSPERO database under file number #78685765 (https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=122479).

Eligibility criteria

All articles in French or English on studies that included at least clinical signs of PNI or NP conditions, hand dysesthesia, tactile stimulation programs, and pain outcomes were included in the review. PNI or NP was an inclusion criterion to avoid including allodynia arising from other conditions such as inflammation in acute injuries, whose pathophysiological mechanisms must be different from those involved in nerve injuries. We have included studies related to complex regional pain syndrome (CRPS) as type II CRPS is associated with a known nerve injury, and type I CRPS shows clinical characteristics of neuropathic pain.[14,15] A tactile stimulation program was defined as a rehabilitation modality using mechanical stimulation (eg, touch or vibration) on the skin, applied by a health care professional and/or taught to a client as part of a home program. Exclusion criteria were as follows: a) examination of only cold or heat dysesthesia; b) polyneuropathy or phantom limb pain as a primary diagnosis; c) dysesthesia secondary to chemotherapy; and d) studies on healthy subjects, newborns, or animals. Commentaries, narrative reviews, clinical practical guidelines, and conference abstracts were excluded. Studies not published in English or French were excluded due to the cost and time involved with translation.

Sources of information and search strategy

A systematic review was conducted from the inception of each database to January 1, 2020 with consultation from an information specialist using the following databases: Medline, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Cochrane Library. These databases were selected because of the volume and variety of health care articles indexed. The keywords used to conduct the search included the following: dysesthesia, allodynia, paresthesia, hyperesthesia, hyperalgesia, hyperesthetic, sensory, cutaneous, skin, tactile, superficial, somatosensory, touch, vibration, stimulation, reeducation, re-education, and rehabilitation. Various combinations of these keywords were entered into each database in sequential order to achieve optimal results. For example, the Medline search was as follows: (exp Paresthesia/OR exp Hyperesthesia OR exp Hyperalgesia OR (dysesthesi* OR hyperesthesi* OR allodyni* OR paresthesi* OR hyperestheti* OR hyperalg*).ab,kf,kw,ti.) AND (((cutane* OR skin OR tactile* OR superficial OR sensory OR somatosensory OR vibrat* OR touch*) ADJ2 (stimulat* OR reeducat* OR rehabilitat* OR re-educat*)).ab,kf,kw,ti.) OR ("desensiti*".ab,kf,kw,ti.)). A manual database search was also done using reference lists of relevant scientific articles and reviews of additional articles.

Selection of studies

The initial list of references was imported into Endnote, a bibliographic management software program. Once duplicate references were removed, two reviewers (IQ, AC or IQ, JOD) selected relevant references. All titles of references were screened and reviewed for eligibility. The abstracts of references whose titles seemed relevant were checked to further validate the eligibility criteria. Copies of full-text articles whose abstracts seemed to meet the eligibility criteria were obtained and read in their entirety for initial selection, and then for an in-depth review, quality assessment, and final selection. Discrepancies were either discussed until a consensus was reached or resolved by a third independent reviewer (J.O.D. or D.B.).

Data collection process

Two independent reviewers (I.Q., A.C. or I.Q., J.O.D.) used a data extraction form to summarize and interpret key aspects identified during the review of the selected studies. These included study design, patient characteristics (injury or health condition, duration of symptoms before intervention, PNI, or NP), sample size, intervention characteristics, outcome measures, follow-up time, outcomes (quantitative and qualitative), and study quality. Outcomes related to pain intensity, allodynia surface, allodynia severity, and cases where allodynia was resolved were extracted. This information was tabulated using an Excel spreadsheet. When articles addressed heterogeneous sites of dysesthesia, hand dysesthesia information was extracted separately whenever possible. Authors were contacted to retrieve additional information on the hand dysesthesia subgroup and on the intervention if it was possible. Data extraction discrepancies between the two reviewers were

either discussed until a consensus was reached or resolved by a third independent reviewer (J.O.D. or D.B.).

Summary measures of quantitative data including measures of central tendency and variability, as well as mean differences and effect size, were extracted whenever possible. Measures were considered statistically significant if the 95% confidence interval did not include zero (0) and/or the p-value was ≤ 0.05.

Quality and risk of bias assessment

Study quality was assessed using the Methodological Index for Non-Randomized Studies (MINORS). This index has good internal consistency ($\alpha = 0.73$), moderate-to-good interreviewer agreement ($k = 0.61$-1.00), and test-retest reliability ($k = 0.59$-1.00).[16] MINORS is a 12-item standardized tool used to determine the methodological quality of nonrandomized studies. Each item of this tool is given a score of 0 ("not reported"), 1 ("reported but inadequate"), or 2 ("reported and adequate"). The items examine the following: the aim of the study, inclusion of patients, prospective collection of data, appropriate and unbiased endpoints of the study, follow-up period, loss to follow-up, and prospective calculation of the sample size. The scores are added together, with maximum total scores reaching 16 or 24 for noncomparative and comparative studies, respectively. Blind scoring was conducted independently by both reviewers (IQ, AC or IQ, JOD). Discrepancies were either discussed until a consensus was reached or resolved by a third independent reviewer (JOD or DB).

Risk of bias was assessed by one reviewer (IQ) and reevaluated by two reviewers (DB, JOD). This was done for each of the 11 studies in accordance with the five principal types of bias: selection, performance, attrition, detection, and reporting.[17] Those risks of bias were classified as low, moderate, or high.

Results

The search strategy identified 1534 studies, including 827 in Embase, 521 in Medline, 186 in CINAHL, and 0 studies in Cochrane. Once the duplicates were removed and the titles and abstracts were screened, 42 potential studies remained. Figure 1 shows the flow diagram for the search results. Eleven studies[18-28] were selected for this systematic review based on the inclusion and exclusion criteria. Three of the selected studies were prospective case-series studies.[20,22,23] One of those three studies also included a small multiple case report.[23] Three studies were retrospective case-series studies,[24-26] three studies were case report studies,[19,27,28] one study was an experimental study,[21] and one other study was a proof-of-concept study.[18] Therefore, the final 11 studies included in this systematic review were all uncontrolled studies.

Study characteristics

Key study characteristics are summarized in Table 1. The studies were classified in chronological order by type of intervention and within the same intervention. Six studies examined the use of a

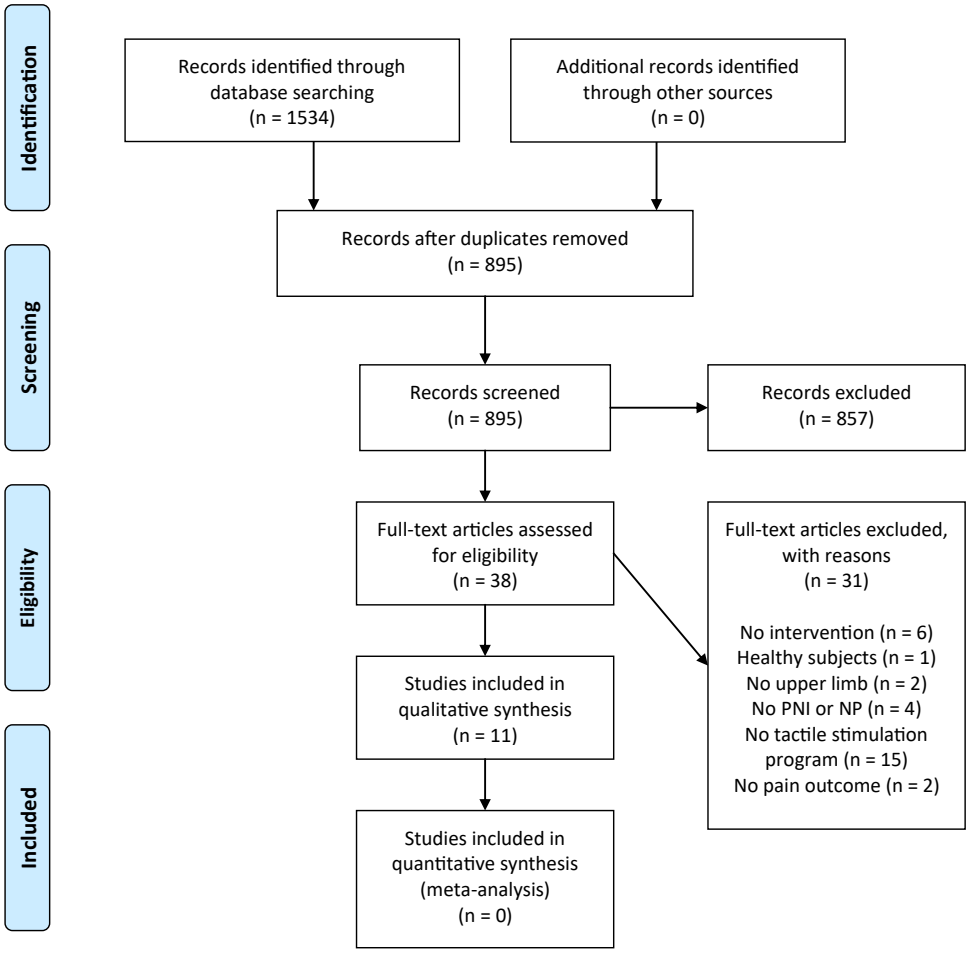

Fig. 1. PRISMA flow diagram of literature search and selection process.

Table 1
Key characteristics of each study

Study Article (date)	Study type	Population	Intervention	Outcome measures	Follow-up time	Results	MINORS score
Bellugou et al (1991)[18]	PC	Hand injury n = 60 participants Pain duration[a]: Unknown PNI: Authors suggest that all participants have at least lesions affecting sensory receptors NP: Authors report painful hypersensitivity in all patients	D	Pain: Descriptive	6-7 weeks	Pain 85% to 90% of participants showed reduction in pain or no pain ("complete healing") 10% of participants showed no improvement in pain Reduction in pain can be observed within 2 to 3 weeks, with a maximum decrease within 6 to 7 weeks	2
Menck et al (2000)[19]	CR	Upper extremity CRPS type I n = 1 participant Pain duration[a]: 5 months PNI: Suspected because of CRPS I diagnosis NP: Suspected because of reported paresthesia (numbness, tingling)	D	Pain: NRS Allodynia: Descriptive	3 months	Pain: NRS: Decrease in pain intensity Initial: 6 10th week: 3 Allodynia:Initial: Present 10th week: Resolved	4
Pleger et al (2005)[20]	PCS	CRPS type I with symptoms affecting the whole hand n = 6 participants Pain duration*: 18.3 months (range: 1-52) PNI: Negative ENMG, but suspected because of CRPS I diagnosis NP: Allodynia and/or hyperalgesia mentioned for all participants	D	Pain: NRS	1 to 6 months	Pain: Decrease in pain intensity ($P = .04$) First measurement: 5 ± 2.9 Second measurement (1-6 months): 1.2 ± 1.4	4
Love-Jones et al (2009)[21]	ES	Neuropathic pain patients with different etiologies and body parts affected n = 18 participants Pain duration[a]: 27 months (range: 3-336) PNI: $n = 6$ medically diagnosed (postherpetic neuralgia) NP: Reported by all participants	D	Evoked pain: NRS Allodynic area: Marked out the area with a cotton swab then marked out a grid using perforated bubble wrap	Reevaluated every 10 min postintervention for up to 1 h	This study differentiated responders (R) from nonresponders (NR). R is defined as having more than 30% reduction in the allodynic area Pain: No significant change in evoked pain intensity at any point post-treatment in both R and NR. R: NRS −0.1 mm ± 0.6 ($P > .05$) ($n = 9$) NR: NRS −0.1 mm ± 0.8 ($P > .05$) ($n = 9$) Allodynic area: maximum area shrinkage was seen 20 min post-treatment in R. R: Shrinkage of 48% ± 9% ($P < .001$) of the area ($n = 9$)	10
Göransson & Cederlund (2011)[22]	PCS	Hand and upper extremity injury n = 39 participants Pain duration[a]: 9 weeks (range: 3-104) PNI: Medically diagnosed ($n = 10$) NP: Not able to differentiate nociceptive pain from NP	D	Pain: VAS Hypersensitive area: Drawn out by patient then measured	6 weeks	Pain with use/touch: Significant decrease VAS: −15 mm [95%CI: −30, −7] ($P < .001$) Pain at rest: significant decrease VAS: −6 mm [95%CI: −18, 0] ($P = .001$) Hypersensitive area: significant decrease Area: −850 mm^2 [95%CI: −1696, −300] ($P < .001$)	10

Table 1 (*continued*)

Study Article (date)	Study type	Population	Intervention	Outcome measures	Follow-up time	Results	MINORS score
Lewis et al (2011)[23]	PCS	CRPS type I n = 4 participants (2 out of 4 with upper limb affected) Pain duration[a]: 15 months (range: 7-31) PNI: Suspected because of CRPS I diagnosis) NP: All participants reported allodynia	D	Pain: Brief pain inventory (BPI) Allodynic mapping: With a cotton bud and measurements of the boundaries from an anatomical landmark.	Up to 2 weeks after program.	Pain: Mean BPI decrease for the 4 participants Baseline: 6.3 Up to 2 weeks after intervention: 5.8 Allodynic mapping: Up to 2 weeks after intervention: A mean shift distally from the allodynic area by 80 mm for the 4 participants.	5
	MCR	Case report #1 CRPS (type not mentioned) after index finger amputation n = 1 participant Pain duration[a]: 14 months PNI: Assumed (digital nerves are injured with the amputation) NP: All participants reported allodynia	D	Allodynia: Descriptive	10 months	Initial description: Allodynia from the midpoint of the upper arm distally Final description: Allodynia resolved to the point of being able to tolerate touching along his whole limb. Area of tenderness persisted around his thumb.	
		Case report #2 CRPS type II postsurgical repair of digital common nerve (middle and ring fingers). n = 1 participant Pain duration[a]: 8 months PNI: Injured nerves diagnosed NP: Participant reported allodynia	D	Pain: Descriptive Allodynia: Descriptive	5 months	Initial description: -Incessant pain -Allodynia in area between her ring finger and middle fingers, extending the length of the fingers and over the fingertips. Final description: -Intermittent pain -Decrease of allodynia: Restricted to a small area on the ulnar border of the middle finger around the PIP joint.	
Spicher et al (2008)[24]	RCS	Neuropathic pain patients (different etiologies and body parts affected) n = 43 participants Pain duration[a]: 35 months (SD 21, range: 7-523) PNI: Injured nerves identified, not medically diagnosed NP: Reported by all participants	SRM	Allodynia surface: Allodynography (mapping) with a 15 g S–W monofilament and VAS Allodynia severity: Rainbow pain scale (with S–W monofilament)	Time required to eliminate the allodynia (and treat hypoesthesia)	Mechanical allodynia: Disappearance of allodynia in all participants within an average of 70 ± 66 days (8-206) Note: To be included in this retrospective study, participants had to demonstrate disappearance of allodynia. Allodynia severity: Overall duration to move on to the next monofilament: 24 days From green (1.5 g) to blue (3.6 g): 49.9 days ± 32.9 From blue (3.6 g) to indigo (8.7 g): 33.7 days ± 20.8	9

(*continued on next page*)

Table 1 (*continued*)

Study Article (date)	Study type	Population	Intervention	Outcome measures	Follow-up time	Results	MINORS score
Nedelec et al (2016)[25]	RCS	Burn survivors with different body parts affected n = 17 participants (15 with allodynia out of a total of 17, *n* = 4 hands) Pain duration[a]: 486 days (SD 596, range: 45-2373) PNI: Assumed (receptors minimally injured as a result of burns) NP: All participants described symptoms compatible with neuropathic pain	SRM	Pain: QDSA Size of area affected by mechanical allodynia: Allodynography with a 15 g S–W monofilament (and VAS) and descriptive Mechanical allodynia threshold: Rainbow pain scale (expressed in percent of improvement) and descriptive	2 to 3 months	Pain: Reduction in QDSA score (converted to % from baseline) At 1 month: −3.1% ± 7.7 (*n* = 8) At 2 months: −8.9% ± 14.1 (*n* = 8) At 3 months: −22.7% ± 22.8 (*n* = 6) Size of area affected by mechanical allodynia: At 3 months: Significant reduction (*P* = .002) (*n* = 5) Mechanical allodynia threshold: Improved At 2 months: 27 ± 21% (*n* = 14) At 3 months: 29 ± 26% (*n* = 12) Out of the 15 participants with allodynia, 11 responded well to treatment (reduction in size of area and threshold), including 8 upper limb −injured participants. All hand-injured participants showed resolution of allodynia (*n* = 4). 4 participants did not respond to this treatment (2 shoulders and 2 lower extremities).	6
Packham et al (2018)[26]	RCS	Upper limb with CRPS type II n = 88 nerve lesions (51 of which presented with allodynia) Pain duration[a]: 31 months (range: 1 month - 25 years) PNI: Mentioned, not medically diagnosed NP: All participants had neuropathic pain	SRM	Pain: QDSA Allodynic area: allodynography using a 15 g S–W monofilament and VAS	Time required to eliminate the allodynia (and treat hypoesthesia)	Pain: Reduction in QDSA score (expressed as % of the maximal total QDSA score) Initial score: 48.1 ± 17.7 (range 5-99) Final score: 20.1 ± 20.0 (range 0-75) (At the end of treatments) Significative decrease in pain (*P* < .001) Allodynic area: 49 out of 51 lesions showed a complete resolution of their allodynia In two lesions, treatments were discontinued because the therapist felt they would not be beneficial Average length of treatment to resolve allodynia: 81 days (SD 76.4; range: 5-381)	9
Quintal et al (2018)[27]	CR	Upper limb CRPS type I postwrist ligament tears n = 1 participant Pain duration[a]: 18 months PNI: Suspected because of CRPS type I diagnosis NP: Symptoms (paresthesia and allodynia) compatible with neuropathic pain	SRM	Pain: QDSA (minimum and maximum scores), NRS Allodynic area: allodynography using a 15 g S–W monofilament and VAS, measured in cm^2 (height × width) Allodynia severity: Rainbow pain scale with S–W monofilaments	22 months	Pain: Reduction in QDSA score (/64) Initial: min: 17; max: 40 At 22 months (final): min: 8; max: 14 Reduction in NRS score: Initial: At rest min: 6; max: 7 At 22 months (final): At rest min: 0; max:3 Allodynic area Initial: Too spread out to measure it At 2 months: 120 cm^2 At 9 months: 0 cm^2 (resolved) Allodynia severity: Initial: Red (0.03 g) At 9 months: Resolved (no pain with 15.0 g)	4

Table 1 (*continued*)

Study Article (date)	Study type	Population	Intervention	Outcome measures	Follow-up time	Results	MINORS score
Wider et al (2006)[28]	CR	Painful hand and moving fingers n = 1 participant Pain duration*: Not specified, but at least 7 months and at most 14 months PNI: Medically diagnosed (carpal tunnel syndrome) NP: Participant reported hyperalgesia	Use of a glove and tactile stimulation	Pain: Qualitative	Not specified	Pain: Immediate and complete disappearance of pain upon tactile stimulation or use of a glove.	2

PC = proof of concept; ES = experimental study; PCS = prospective case series; RCS = retrospective case series; CR = case report; MCR = multiple case reports; CRPS = complex regional pain syndrome; PNI = peripheral nerve injury; NP = neuropathic pain; ENMG = electroneuromyography; D = desensitization; SRM = somatosensory rehabilitation method; NRS = Numeric Rating Scale (/10); VAS = Visual Analog Scale (/100 mm); QDSA = *Questionnaire de la douleur Saint-Antoine* (/64); BPI = Brief Pain Inventory (pain severity section: mean score/10); S–W monofilament = Semmes-Weinstein monofilament; PIP = proximal interphalangeal.

[a] Duration of symptoms before initiating the intervention.

tactile desensitization program,[18-23] four assessed the use of the Somatosensory Rehabilitation Method (SRM),[24-27] and one examined the use of a glove and tactile stimulation.[28] Each study looked at different populations: hand injuries,[18] hand and upper limb injuries,[22] NP patients with different etiologies ($n = 2$),[21,24] burn survivors,[25] upper limb complex regional pain syndrome type 2,[26] type 1,[19,20,27] or both,[23] and painful hand and moving fingers.[28] Five studies[18-20,27,28] included only hand conditions. PNIs were medically diagnosed in four studies,[21-23,28] but in the study by Lewis et al.,[23] PNI was only diagnosed in one participant. PNIs were inferred (rather than medically diagnosed) in seven studies.[18-20,24-27] NP was mentioned (but not medically diagnosed) in five studies,[21,24-27] and it was inferred in five studies.[18-20,23,28] One study mentioned not being able to differentiate nociceptive pain from neuropathic pain.[22] The study characteristics, including type of population and intervention, were mostly heterogeneous across all studies selected.

Interventions characteristics

The specific characteristics of the interventions used in each study are detailed in Table 2. All six desensitization studies[18-23] described the interventions and the grading or tailoring of the parameters in detail. In each of these studies, the various intervention parameters (material, intervention frequency and duration, stimulation territory) were generally described. Five studies[18-20,22,23] recommended adjusting the parameters to the patients' symptoms (ie, no pain increase or as tolerated) while the other study[21] suggested that adjustments should match the maximum pain tolerated by patients. Clinical decision criteria for ending the treatment was not described in any study. Overall, the studies that addressed desensitization described heterogeneous interventions.

In terms of SRM studies, all four articles[24-27] provided detailed descriptions of a standardized intervention procedure, with nearly the same parameters for material, frequency, and duration of stimulation. However, the stimulation territory was determined based on the allodynic area being assessed. All four studies recommended not to increase the pain level during the program, because the stimulation territory should be comfortable to the touch and contact with the dysesthesic area should be avoided. Most patients reported hypoesthesia in the same cutaneous area where the allodynia was previously observed. This was the case in all four SRM studies.[24-27] These studies advocated to systematically continue the intervention, treating hypoesthesia with tactile stimulation directly on the area affected. For the study that examined the use of a glove and tactile stimulation,[28] no details on the intervention were provided. Of the eleven studies included, two of them[19,27] provided a detailed description of other concurrent interventions, and three of them[18,22,25] briefly mentioned whether or not other concurrent interventions were used. The study by Lewis et al[23] did not provide any information on other interventions for the case series but did provide details of concurrent interventions for the case reports. Four studies only provided a thorough description of medication as a concurrent intervention.[19,20,27,28] Three studies did not provide any information on concurrent interventions.[21,24,26]

Outcome measures

Detailed information on outcomes measures is presented in Table 1. Three studies only reported on pain outcomes,[18,20,28] one study focused solely on dysesthesia-specific outcomes,[24] and seven studies reported on both pain and dysesthesia outcomes.[19,21-23,25-27] Pain outcomes were measured with the Numerical Rating Scale (NRS),[21] the Visual Analog Scale (VAS),[22] the Brief Pain Inventory (BPI),[29] and the McGill Pain Questionnaire or the French version of that tool, the *Questionnaire de la douleur Saint-Antoine*.[25,26] Three studies used a detailed subjective assessment of pain.[18,23,28] Of the studies assessing dysesthesia, seven employed a variety of area measuring techniques (Table 1).[21-27] Three SRM studies assessed change in allodynia severity using a selection of Semmes-Weinstein monofilaments, with the severity being measured categorically with the most severe allodynia elicited by a smaller monofilament.[24,25,27] The four SRM studies provided the number of cases where allodynia had resolved.[24-27] Two studies used a detailed subjective assessment of allodynia.[19,23] Five studies assessed concepts other than pain (ie, range of motion and strength,[19,27] temperature, color, and edema,[19] body perception,[23] occupational performance,[22,23,27] and changes in primary cortex[20]), yet that goes beyond the scope of this review. Although all eleven studies assessed pain and/or dysesthesia, this was done using heterogeneous outcome measures.

Length of follow-up varied greatly, including 60 min,[21] one to 10 months,[19,20,22,23,25] 22 months,[27] or the amount of time needed to achieve rehabilitation goals.[24,26] Follow-up time was not specified in two of the studies.[18,28]

Table 2
Description of intervention according to study

Study Author (date)	Type	Intervention (setting)	Description	Parameters	Adjustments	Other interventions
Bellugou et al (1991)[18]	D	Particles Textures Vibration Heated sand Paraffin bath Hydrotherapy Other therapies: LFUS, massage (Not specified whether done at home or in clinic)	Particles: With multiple very light stimuli. The patient places his/her hand in a box with various particles (e.g., rice, chickpeas) and moves his/her fingers in it. Textures: With various textures (cotton, velvet, Velcro) barely sweeping the skin. Ideally, the patient stimulates the sensitive area himself/herself with the texture in his/her healthy hand. Otherwise, the patient can use the injured hand to touch the texture directly, or the texture is placed on a wood stick and the therapist rubs it on the patient's sensitive skin. A series of brushes ranging from soft to coarse (Garros clavier) can also be used. Vibration: With a vibration generator. Heated sand flow: With fine sand particles in a bin, bombarding the hand Paraffin bath: With paraffin wax and paraffin oil at a temperature of 38°C in a bin. The patient quickly dips his/her hand into the bin, allows the paraffin to dry for 3-4 s, then repeats this procedure 5-6 times. Hydrotherapy: With heated sterile water. The patient manipulates a soft sponge with his/her hand. Other therapies (LFUS, massage): Not described.	Textures/Particles: 3-4×/day for 10 min Vibration: 2-3×/day for 10 min Heated sand flow: Not described Paraffin bath: 5 min Hydrotherapy: Not described Other therapies (LFUS, massage): Not described	Particles: Finger movements and types of particles are adjusted as the intervention should not increase the pain felt: progression of particles to more coarse, bigger and/or heavier particles. Textures: Types of textures are adjusted as the intervention should not increase the pain felt. Vibration: Frequency and amplitude of vibration is adjusted in order to not provoke pain. Also, if the targeted area is painful, the vibration is applied to an adjacent area. The session is stopped whenever pain is felt. Heated sand flow: The patient places his/her hand and forearm relatively deep into the bin or removes it completely to not provoke pain. Paraffin bath: This technique is contraindicated if it is not tolerated. Hydrotherapy: Temperature of water is modulated to be tolerated.	Massage, hand therapy, motor reeducation for some patients
Menck et al (2000)[19]	D	Textures (home) Massage (home) Thermal (home) Soft tissue mobilization (home) Resistance exercises (home)	Textures: Towel rub on the left hand Massage: Self-touch light massage Thermal: Contrast baths (warm/cold). Soft tissue mobilization: On the dorsum of the hand. Resistance exercises: Resisted grasp with theraputty.	Textures: 5×/day Massage: 5×/day Contrast baths: 3×/day Soft tissue mobilization: Not described. Resistance exercises: Not described (no duration specified for any of the treatment modalities)	Treatment modalities are adjusted throughout the weeks of treatment starting with soft modalities the first 3 weeks and gradually increasing the intensity of the stimulations (eg, rougher textures, more resistance) Contrast baths: During the first 3 weeks Soft tissue mobilization: week 4 to week 9. Resistance exercises: week 4 to week 12.	Medication: Daypro and Vicodin. Then at week 5, medication was changed to Neurontin. Physical therapy (3×/day for 12 weeks): Movement reeducation, aerobic conditioning, dynamic strength and coordination exercises, passive range of motion, edema management, vertebral manipulation, proprioceptive neurofacilitation, use of orthotic devices. Psychological therapy.
Pleger et al (2005)[20]	D	Pain-adapted sensorimotor protocol including: Sensory tasks Motor tasks Orthotic device (Not specified whether done at home or in clinic)	Sensory tasks: Soft cushioning, bandaging, immersion of the hand in substances, application of fabrics (cotton wool, soft fabrics, paint brushes, balls) application of warmth/coolness, identification of surface structures and forms, stereognosis (and coordination) with the affected limb. Motor tasks: Immobilization, grasping of objects, ADL, swinging movements, writing, arts and crafts activities, resistance exercises, fine-motor skill training Orthotic device: Type not described.	Pain-adapted sensorimotor protocol: 2-3×/day for 15-30 min (For 3-4 days/week)	Pain-adapted sensorimotor protocol: Graded with 4 possible pain-adapted levels of therapy (P0-P3) chosen according to the pain intensity reported by the patient for sensory/motor tasks and for the orthotic device. Motor tasks: With nonaffected upper limb for P3 (pain >5 on NRS, then with affected upper limb for the other levels (P1-P3)	Medication: Celecoxib given to one patient, valdecoxib & gabapentin given to the other patient.

Table 2 (*continued*)

Study Author (date)	Type	Intervention (setting)	Description	Parameters	Adjustments	Other interventions
Love-Jones et al (2009)[21]	D	Repeated tactile stimulation (clinic) Repeated heat pain stimulation (clinic)	Repeated tactile stimulation: The clinician strokes a cotton swab on the sensitive area and in a control mirror territory. Repeated heat pain stimulation: A thermode is applied to the affected side (or mirror areas)	Repeated tactile stimulation: 10×, within 1 min At a speed of 2-3 cm/s Repeated heat pain stimulation: 1× for 2 min 10 heat ramps (2°C/s up to the HPT and sustained for a further 4s, as tolerated)	Repeated tactile stimulation: Stimulation territory is adjusted as the patient feels maximum tolerable pain. Repeated heat pain stimulation: Stimulation territory is adjusted as tolerated.	Not described.
Göransson & Cederlund (2011)[22]	D	Textures (home)	Textures: Ranging from soft cotton to Velcro hooks. Massage with textures in the same direction, within the hypersensitive area, using the same speed and pressure every time until numbness occurred.	Textures: 3×/day, 2-5 min	Textures: Type of texture is initially chosen so that it is barely tolerated. After 1-3 weeks, most patients could progress to a rougher texture and still tolerated it.	OT treatment: Home program updated; not otherwise described. 2-8×/month
Lewis et al (2011)[23]	D	PCS Textures (home)	Textures: Up to 5 out of 8 textures are applied on the affected upper limb, ranging from soft to coarse.	Textures: 6-8×/day (recommended) for 1-5 min Participants carried out the program an average of 4.5×/day, with an average of 5 min per session	Textures: Textures are chosen so that they are perceived as tolerable. During the program, patients could progress to rougher textures, could increase the duration of skin contact, and could move the stimulation more distally (i.e., closer to the allodynic area).	Not described.
		MCR CR #1 Textures (home & clinic) Sensory boxes (home & clinic) CR #2 Textures (home & clinic) Sensory boxes (clinic)	CR #1 Textures: 3 out of 9 textures applied just above the border of the allodynic area, then on the allodynic area itself (hand). Sensory boxes: Hand is immersed into fillings of different weights and qualities. CR #2 Textures: 3 textures out of 10. Sensory boxes: Not described.	CR #1 Textures: ≥4×/day for 5 min Sensory boxes: Performed daily; not otherwise described. CR #2 Textures: ≥4×/day for ≤5 min	CR #1 Textures: Should be comfortably tolerated; territory of application is chosen so it is tolerated by the patient. Sensory boxes: Not described. CR #2 Textures: Not described. Sensory boxes: Not described.	CR #1 Daily: Hydrotherapy, physiotherapy, occupational therapy, and psychological support. Wax therapy, hand strengthening, cooking therapy, writing exercises. CR #2 For the 1st week: Daily wax therapy, hand strengthening and dexterity exercises. The patient was also encouraged to look at her hand/arm and watch other people's hands. Week 7 and 8: Visualization exercises, hand exercises (including biometrics program), diaphragmatic breathing exercises, wax therapy, putty exercises.
Spicher et al (2008)[24]	SRM	DVCS with textures (home) DVCS with vibration (clinic) Precautionary advice (clinic) and application (not described) Rehabilitation of the hyposensitivity (and underlying hyposensitivity) (not described)	DVCS with textures: OT shows the patient how to apply textures in the appropriate cutaneous territory perceived as comfortable. DVCS with vibration: Not described. Precautionary advice and application: OT shows the patient how to avoid contact with the allodynic area. Rehabilitation of hyposensitivity (and underlying hyposensitivity): Not described	DVCS with textures: Rabbit skin 6×/day for 2 min DVCS with vibration: 1×/week Frequency: 100 Hz Amplitude: 0.06 mm Duration not specified Precautionary advice: Each therapy session 1×/week Rehabilitation of hyposensitivity (and underlying hyposensitivity): Not described	DVCS: Territory for vibration and textures is adjusted as it is perceived comfortable. “During the course of treatment, it will become possible for the patient to progressively invade the ‘old’ allodynic territory with the same comfortable stimulus.” Precautionary advice: Defined at each therapy session. Rehabilitation of hyposensitivity (and underlying hyposensitivity): Not described	Not described.

(*continued on next page*)

Table 2 (*continued*)

Study Author (date)	Type	Intervention (setting)	Description	Parameters	Adjustments	Other interventions
Nedelec et al (2016)[25]	SRM	DVCS with textures (home) DVCS with vibration (clinic) Precautionary advice (clinic) and application (home) Sensory reeducation for hypoesthesia (home and clinic)	DVCS with textures: The patient applies fur or a soft, comfortable fleece to a territory proximal from the allodynic area. DVCS with vibration: The same territory is stimulated with a vibration generator. Precautionary advice and application: OT records the patient's daily activities and treatments (eg, pressure garments, massage, etc.) where direct pressure might be applied to the allodynic area. Using problem-solving collaboration, they find "alternative approaches so that pressure stimulation could be avoided during activities/ treatments while accomplishing the daily activities, or alternatively, determine that the activities should be discontinued or delegated until the mechanical allodynia is eliminated." Sensory reeducation for hypoesthesia: Once the allodynia is resolved, sensory reeducation is initiated. Touch discrimination is performed with the eraser end of a pencil and requires the patient to discriminate when he/she is being touched, whether it is static Touch or moving in a straight/ curved line, with their vision obscured. Texture perception is performed with three different textures that the patient perceives as comfortable directly on the hypoesthesia area and to a normal control anatomically similar territory. Vibratory stimulation is performed with a vibration generator (in the clinic) or with another device at home (eg, hand-held vibrator) on the hypoesthesia area.	DVCS with textures: 8×/day for 1 min DVCS with vibration 1×/week for 10 min Precautionary advice: Revised during therapy session with the patient every 2 weeks Precautionary application: Should be applied at all times Sensory reeducation for hypoesthesia: Touch discrimination: 12×/day for 15 s, then gradually progressing to 3×/day for 10 min Textures: 12×/day for 15 s, then gradually progressing to 4×/day for 5 min Vibration: 1×/week (clinic), 5 min maximum 1×/day (home), 5 min maximum	DVCS with textures: Types of textures and stimulated area adjusted as it is perceived as comfortable. The targeted territory is revised every 2 weeks. DVCS with vibration: Territory of application and intensity of the vibration are adjusted as they are perceived as comfortable. The targeted territory is revised every 2 weeks. Precautionary advice and application: Personalized for every patient, revised every 2 weeks. Sensory reeducation for hypoesthesia: Touch discrimination begins with a static touch or moving in a straight line, then when the person can discriminate those touches, a curved line is added to the exercises. Textures are applied if the person is able to perceive 5 g (between 4.56 and 4.74 monofilament). The vibration generator is set at 100 Hz and the amplitude adjusted to 0.1 mm above the level the person could perceive. Excessive painful vibratory stimulation is avoided.	Cortisone injection ($n = 3$) Not otherwise described.
Packham et al (2018)[26]	SRM	DVCS with textures (home) DVCS with vibration (clinic) Precautionary advice (clinic) and application (home) Sensory reeducation (not mentioned)	DVCS with textures: A comfortable texture (eg, rabbit fur, plush microfleece), is applied using a light stroking motion to an territory of the skin with normal sensation, in the area of the identified injured nerve. DVCS with vibration: Vibration stimulation is applied to the same territory as DVCS with textures, using a vibration generator. Precautionary advice and application: OT reviews activities of daily living with the participant and together they identify sources of evoked pain (eg, rubbing of clothing and use of tools). They find "strategies to avoid stimulation and/or delegate provocative tasks," to "minim [ize] the risk of eliciting pain by temporarily limiting touch and consequently functional use of the painful" area. Sensory reeducation: To address the residual hypoesthesia	DVCS with textures: 8×/day for 1 min maximum DVCS with vibration: 1×/week for 10 min Precautionary advice: At every appointment Precautionary application: Applied at all times Sensory reeducation: Not described	DVCS with textures: Territory stimulated, type of texture and duration of stimulation is adjusted so the participant perceives it as "the most comfortable." DVCS with vibration: Territory of application and intensity are adjusted for normal sensation. Precautionary advice: Strategies are personalized for every participant and chosen to minimize pain. Sensory reeducation: After the allodynia has abated	Not described.

Table 2 (*continued*)

Study Author (date)	Type	Intervention (setting)	Description	Parameters	Adjustments	Other interventions
Quintal et al (2018)[27]	SRM	Tactile stimulation at distance (home and clinic) Precautionary advice (clinic) and application (home) Direct stimulation (home and clinic)	Tactile stimulation at distance: A comfortable light fabric (Fur) is applied on a proximal territory at a distance from the allodynia zone. Precautionary advice and application: "Encourage the patient to adhere to the precaution of avoiding touching" Direct stimulation: Stimulation of the previously allodynic area that is now hypoesthesic, "with soft fabrics and light mechanical vibration by a vibration generator."	Tactile stimulation at distance: 8×/day for 1 min maximum Precautionary advice and application: Not described. Direct stimulation: Starting with 12×/day for 15 s, progressing to 4×/day for 5 min.	Tactile stimulation at distance: Territory of skin stimulation is chosen to not evoke pain. Progression of the territory stimulated is done from proximal portion to the distal portion of the limb affected. Precautionary advice and application: Not described. Direct stimulation: Carried out in a progressive way, from more frequent with less duration to less frequent with more duration.	Medication (pregabalin, celecoxib). Pain management modalities applied on a neighboring zone from the allodynia area (transcutaneous nerve stimulation, cryotherapy) and heated gloves. Pain management education (breaks). Graded motor imagery program. Active range of motion exercises. Strength exercises. Task simulations.
Wider et al (2006)[28]	Other	Use of a glove Tactile stimulation (Not specified whether done at home or clinic)	Use of a glove: Not specified Tactile stimulation: In the painful area. Not otherwise specified.	Use of a glove: Not specified Tactile stimulation: Not specified	Use of a glove: Not specified Tactile stimulation: Not specified.	Treatment with medication (gabapentin, amitriptyline, and baclofen). Not otherwise described.

D = desensitization; SRM = somatosensory rehabilitation method; NRS = numeric rating scale; VAS = Visual Analog Scale; QDSA = *Questionnaire de la douleur Saint-Antoine*; PCS = prospective case series; MCR = multiple case report; CR = case report; OT = occupational therapist/therapy; DVCS = distant vibrotactile counter stimulation; LFUS = low-frequency ultrasound; ADL = activities of daily living.

Changes in pain/dysesthesia

Five studies presented a statistical analysis of pain/dysesthesia outcomes (Table 1) and showed statistical differences between treatment initiation and the last day of follow-up. With respect to desensitization, Pleger et al (2005)[20] found a statistically significant decrease in pain intensity ($P = .04$). Göransson and Cederlund (2011)[22] found a statistically significant improvement in pain with use or on contact (ie, touch) ($P < .001$), reduced pain at rest ($P = .001$), and reduced size of the hyperesthetic area ($P < .001$). Love-Jones et al (2009)[21] found a statistically significant decrease in the size of the allodynic area ($P < .001$) but did not find a statistical difference in pain scores. In terms of the SRM studies, Nedelec et al (2016)[25] found a statistically significant decrease in the size of the allodynic area ($P = .002$). Packham et al (2018)[26] found a statistical difference in pain scores ($P < .001$) with a strong effect size (Cohen's d: 1.64) for this variable following the entire tactile stimulation program used to treat allodynia and hypoesthesia. The other studies reported quantitative or qualitative improvements in pain scores and/or dysesthesia but did not perform a statistical analysis. Overall, all studies reported improvements in pain/dysesthesia, but some did not document these findings statistically. It was not possible to conduct a statistical synthesis (meta-analysis) of the results due to the heterogeneous characteristics (populations, interventions, outcome measures, follow-up) across studies.

Quality of selected studies

The MINORS scale scores for quality of research ranged from 2 to 10 out of a maximum score of 16 for noncomparative studies. Two studies[18,28] had a score of 2, one study[19] had a score of 3, two studies[20,27] had a score of 4, one study had a score of 5,[23] one study[25] a score of 6, two studies[24,26] a score of 9, and two studies[21,22] a score of 10. Ratings are presented in Table 3. Six studies clearly stated their research aim/objective.[20-22,24-26] Four studies[21,22,24,26] mentioned the inclusion of consecutive patients.

Table 3
Distribution of the 11 articles included in the review according to the number of articles having obtained one of the three scores (0, 1, 2) for each item of the MINORS scale

Items	Scores for each study (/2)										
	Bellugou et al (1991)[18]	Menck et al (2000)[19]	Pleger et al (2005)[20]	Love-Jones et al (2009)[21]	Göransson & Cederlund (2011)[22]	Lewis et al (2011)[23]	Spicher et al (2008)[24]	Nedelec et al (2016)[25]	Packham et al (2018)[26]	Quintal et al (2018)[27]	Wider et al (2006)[28]
1 - A clearly stated aim	1	1	2	2	2	1	2	2	2	1	1
2 - inclusion of consecutive patients	0	0	0	2	2	0	2	0	2	0	0
3 - prospective collection of data	0	0	1	2	2	1	0	0	0	0	0
4 - endpoints appropriate to the aim of the study	0	1	1	1	1	1	1	1	2	1	1
5 - unbiased assessment of the study endpoint	0	0	0	1	0	0	0	0	0	0	0
6 - follow-up period appropriate to the aim of the study	1	1	0	1	1	1	2	2	2	2	0
7 - loss to follow-up less than 5%	0	0	0	1	2	1	2	1	1	0	0
8 - prospective calculation of the study size	0	0	0	0	0	0	0	0	0	0	0
Total score (/16)	2	3	4	10	10	5	9	6	9	4	2

Table 4
Risks of bias for each study

Study	Selection	Performance	Attrition	Detection	Reporting
Bellugou et al (1991)[18]	Moderate	Moderate	Moderate	High	High
Menck et al (2000)[19]	High	Moderate	High	High	High
Pleger et al (2005)[20]	Moderate	Moderate	High	High	High
Love-Jones et al (2009)[21]	Moderate	Moderate	Moderate	High	High
Göransson and Cederlund (2011)[22]	Moderate	Moderate	Moderate	High	Low
Lewis et al (2011)[23]	Moderate	High	High	High	High
Spicher et al (2008)[24]	High	Moderate	High	High	High
Nedelec et al (2016)[25]	Moderate	Moderate	Moderate	High	Moderate
Packham et al (2018)[26]	Moderate	Moderate	High	High	High
Quintal et al (2018)[27]	High	Moderate	High	High	Moderate
Wider et al (2006)[28]	High	High	High	High	High

Two studies involved a prospective collection of data.[21,22] One study[26] showed endpoints appropriate to the aim of the study. No study conducted an unbiased assessment of the study endpoint, except for the study by Love-Jones et al (2009)[21] who performed a single-blind assessment where patients were unaware of the aim of the study. Four studies[24-27] had an appropriate follow-up period and two studies[22,24] reported a loss in the follow-up rate less than 5%. Calculations for determining sample size and power were not performed in any of the studies. Comparator groups were also not used in any of the studies.

Risk of bias

The five types of bias (selection, performance, attrition, detection, reporting) were present in most of the studies, as shown in Table 4. Only one study[22] showed less risk of bias, which was considered high in one category, moderate in three categories, and low in one category. Three of the studies demonstrated greater risk of bias.[24,26,28] Three types of bias (attrition, detection, and reporting) were predominant for a high risk of bias across all eleven studies. These risks of bias were mainly related to the unvalidated assessment tools chosen (*Questionnaire de la douleur Saint-Antoine*, severity of dysesthesia, and size of dysesthetic area) and to the fact that the results were reported only in a descriptive manner.

Discussion

This review summarizes the current evidence on tactile stimulation programs from 11 articles (involving 243 participants in total), for managing hand dysesthesia after a peripheral nerve injury. It also assesses the methodological quality of these studies. Findings may be useful to hand therapists in determining which tactile stimulation program is most appropriate for their clients, and how to apply and adjust parameters for each of these programs.

The significant heterogeneity of the populations between studies makes comparing their results a difficult task. Moreover, in six of the included studies, the population within the study[18,21,22,24,25,28] was heterogeneous. This makes it difficult to isolate the effects on the specific population studied in this systematic review (ie, hand dysesthesia after a PNI). Although there are five studies on CRPS,[19,20,23,26,27] different types of CRPS and different outcome measures were used, making it difficult to pool the results. Most of the eleven studies showed reasonable evidence of a PNI or NP, but only a few met the criteria for a definite diagnosis.[21-23,28] Finally, duration of symptoms before treatment was heterogeneous in four studies,[20,22,25,26] with acute (<3 months) and chronic populations being combined. This heterogeneity suggests that those interventions can be used in a broad spectrum of clients, although acute patients can exhibit spontaneous recovery not related to treatment (ie, neuropraxia).[2,30,31]

Another facet of heterogeneity in the studies reviewed is the essential construct of tactile desensitization, which implies a reduction in sensitivity through exposure. However, exposure was employed in two different ways in the studies selected for our review: 1) direct flooding of tactile stimuli to the painful area with the goal of improving the pain threshold,[18-23,28] which implies an effect at the level of the dorsal horn in the spinal cord[32] and 2) use of tactile stimuli on an adjacent territory where contact was normal to tolerable,[24-27] and intended to provide sensory reeducation, implying an effect at the level of the somatosensory cortex.[20] This second element is also used in the SRM studies and thus reflected in the studies by Nedelec et al, Quintal et al, Packham et al, and Spicher et al.[24-27] However, there is a lack of consensus on any taxonomy related to sensory reeducation (or relearning) and desensitization. A 2011 Delphi process[12] reported 84% of respondents endorsed desensitization by immersing the hand in different textures (ie, flooding) as an essential component of sensory relearning programs; however, the research question did not discriminate between treatment of numbness or dysesthesia after nerve injury.

All 11 studies did not report enough details to allow for replication of these studies. However, most of the studies reported enough detail about the intervention for the study to be replicated in clinical settings. With respect to desensitization, the six studies[18-23] described a wide variety of intervention parameters. As for the SRM studies, the intervention parameters were standardized across the four studies.[24-27] There were no specific details for the use of glove or tactile stimulation.[28] Overall, it seems that the interventions, including desensitization and SRM, were predominantly used in a home setting a few times a day (1-12 times) for a few minutes (<1-10 min) each time. The exercises were generally reviewed with the clinician during appointments. Most of the studies suggested not to increase the level of pain and recommended that the stimulation be tolerable. All in all, it seems that a vast array of dysesthesia interventions can be easily applied in practice, as they require minimal equipment and are primarily carried out as a home program. However, some of the studies reported sufficient detail on cointerventions, and some did not mention whether there were cointerventions. Due to the lack of information in some studies, and the use of numerous concurrent interventions during the tactile stimulation programs in other studies, it is therefore difficult to attribute the reported results exclusively to tactile stimulation programs.

Many outcome measurement tools were used across the 11 studies included in this review. Most of the instruments used, such as the NRS, VAS, BPI, or McGill Pain Questionnaire (QDSA), were neither specific to dysesthesia, nor to neuropathic pain. On the other hand, seven studies[21-27] did use specific measurement tools to assess severity or the area affected by dysesthesia. However,

none of these instruments had been assessed for validity and reliability at the time these studies were conducted, although reliability of allodynography has recently been reported.[33] It is therefore difficult to definitively conclude that the changes measured by these instruments reflect a change in dysesthesia. There was no other available validated instrument for specifically assessing hand dysesthesia when these studies were conducted. Nevertheless, a new tool is currently available to assess hand sensitivity, including dysesthesia and any sensitivity impairment.[34] The statistical analysis performed on pain scores for some of the studies shows statistical significance for reduced pain with desensitization[20-22] and the SRM.[25] The effectiveness of these interventions is unknown as no effect size was reported, except for the study by Packham et al (2018).[26] Follow-up time varied greatly, which made it impossible to compare the results across studies. In all the studies on desensitization,[18-23] the follow-up time was too short. Consequently, the long-term effects of these interventions could not be assessed or reported.

The current literature on this topic is largely centered on small case-series studies, case studies, experimental studies, and proof-of-concept studies. Those noncomparative studies do not allow the effectiveness of interventions or the effect of tactile stimulation programs themselves to be established. Moreover, the 11 studies that comprised this review, including noncomparative studies, used mainly low-quality methodologies. The low scores on the MINORS scale were predominantly due to the lack of a prospective collection of data, an unbiased endpoint, and the prospective calculation of the study size.

With those results reflecting the low methodological quality of the studies, it is not surprising that risks of bias were found across all studies. Although the outcomes of the studies suggest promising benefits, it is difficult to comment on the effect of those interventions described in the literature due to poor methodological quality and significant risks of bias. One study[22] showed improvements in clinical outcomes while being the least likely to be biased compared to the other studies included in this review. Overall, the studies included in this review suggest that interventions based on tactile stimulation would have beneficial effects on pain, such as those measured with VAS. However, it is not possible to confirm that the improvements noted in the studies reached clinical significance since there is as yet no study on the minimal clinically important difference for the VAS score in patients with touch-evoked neuropathic pain after nerve injury.[35] Based on the literature published to date, tactile stimulation programs show low evidence for decreasing hand dysesthesia after PNI.

This review has its limitations. There is currently no consensus in the literature for terminology related to dysesthesia and tactile stimulation program. Dysesthesia and tactile stimulation program keywords were chosen for this systematic review because they are used in broad categories that employ a variety of terms. It is therefore possible that some articles were missed because of the keywords chosen. Studies on persons with type 1 complex regional pain syndrome (CRPS 1) were included, such as those by Lewis et al and Pleger et al,[20,23] because while the current definition for CRPS type 1 specifies the absence of any major nerve lesion, there is emerging evidence for small fiber neuropathy.[36] Furthermore, given the similarity in some features of the pain in CRPS type 1 to pain of neuropathic origin, neuropathic pain medications are considered a first-line treatment for CRPS type 1 in recent clinical practice guidelines.[37] Those same guidelines also recommend desensitization as part of rehabilitation management. Other relevant studies may also have been missed as a result of the exclusion criteria relating to foreign languages.

Conclusions

This systematic review sought to gather evidence on commonly recommended interventions in the treatment of hand dysesthesia in patients after a PNI. The studies reviewed suggest that tactile stimulation programs may play a role in decreasing hand dysesthesia. Nevertheless, this review suggests inconclusive evidence and inconsistent implementation of those tactile stimulation programs. All studies included have a low to very low quality evidence. We suggest that there are two main types of tactile stimulation programs: desensitization and the Somatosensory Rehabilitation Method (SRM). Of these two programs, only the SRM is a standardized intervention. Regardless of the technique chosen, tactile stimulation should be used 1 to 12 times daily for $<$1 to 10 min and should be increased based on the patient's response (tolerable symptoms or no increase in pain). Additional high-quality methodological studies are needed to establish best practices for tactile stimulation programs used to treat hand dysesthesia.

The identified gaps in the current evidence on tactile stimulation programs for hand dysesthesia after a PNI provide an opportunity for future research studies. There is a need for methodologically rigorous retrospective and prospective case series. These future studies should use internationally accepted terminology for hand sensitivity and pain.[5] They should have precise inclusion and exclusion criteria to obtain a more homogenous population identified as having a PNI and/or NP. Studies should measure outcomes with validated assessment instruments related to the concepts being measured. It would also be interesting to assess the effects of those programs on other parameters, such as hand function and quality of life. Finally, randomized controlled trials would accurately determine the effectiveness of tactile stimulation programs for decreasing hand dysesthesia in comparison to traditional treatment and present opportunities for comparing the effectiveness of flooding and relearning approaches.

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Quiz: # 730

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1. The study design is
   a. RCTs
   b. Qualitative
   c. systematic review
   d. prospective cohort
2. The study evaluated_____ in patients following peripheral nerve injury
   a. therapies for reducing touch induced dysesthesia
   b. methods of scoring touch induced dysesthesia
   c. the correlation between paresthesia and dysesthesia
   d. a new technique for treating dysesthesia
3. Data were retrieved from
   a. Cochrane
   b. CINAHL
   c. Embase
   d. all of the above
4. Methodological Quality was assessed using the
   a. WHO guidelines
   b. ASHT guidelines
   c. MINORS
   d. MAJORS
5. The study concluded that there was compelling evidence that tactile stimulation therapy was effective in treating the dysesthesia
   a. true
   b. false

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