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Review

Non-pharmacological interventions for spasticity in adults: An overview of systematic reviews

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ABSTRACT

Objectives: Spasticity causes significant long-term disability-burden, requiring comprehensive management. This review evaluates evidence from published systematic reviews of clinical trials for effectiveness of non-pharmacological interventions for improved spasticity outcomes.

Methods: Data sources: a literature search was conducted using medical and health science electronic (MEDLINE, EMBASE, CINAHL, PubMed, and the Cochrane Library) databases for published systematic reviews up to 15th June 2017. Data extraction and synthesis: two reviewers applied inclusion criteria to select potential systematic reviews, independently extracted data for methodological quality using Assessment of Multiple Systematic Reviews (AMSTAR). Quality of evidence was critically appraised with Grades of Recommendation, Assessment, Development and Evaluation (GRADE).

Results: Overall 18 systematic reviews were evaluated for evidence for a range of non-pharmacological interventions currently used in managing spasticity in various neurological conditions. There is “moderate” evidence for electro-neuromuscular stimulation and acupuncture as an adjunct therapy to conventional routine care (pharmacological and rehabilitation) in persons following stroke. “Low” quality evidence for rehabilitation programs targeting spasticity (such as induced movement therapy, stretching, dynamic elbow-splinting, occupational therapy) in stroke and other neurological conditions; extracorporeal shock-wave therapy in brain injury; transcranial direct current stimulation in stroke; transcranial magnetic stimulation and transcutaneous electrical nerve stimulation for other neurological conditions; physical activity programs and repetitive magnetic stimulation in persons with MS, vibration therapy for SCI and stretching for other neurological condition. For other interventions, evidence was inconclusive.

Conclusions: Despite the available range of non-pharmacological interventions for spasticity, there is lack of high-quality evidence for many modalities. Further research is needed to judge the effect with appropriate study designs, timing and intensity of modalities, and associate costs of these interventions.

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Abbreviations: ADL, Activities of daily living; AMSTAR, Assessment of Multiple Systematic Reviews; BoNT-A, Botulinum toxin-A; CBT, Cognitive-Behaviour Therapy; CCT, Controlled clinical trial; CP, Cerebral palsy; ES, Effect size; FES, Functional Electrical Stimulation; ICF, International Classification of Functioning and Health; GRADE, Grades of recommendation, assessment, development and evaluation; MD, Multidisciplinary; MS, Multiple sclerosis; mCIMT, Modified Constraint-induced Movement therapy; NMES, Neuromuscular Electric Stimulation; OT, Occupational therapy; PT, Physiotherapy; QoL, Quality of life; RCT, Randomised controlled trial; ROM, Range of motion; TMS, Transcranial Magnetic Stimulation; SCI, Spinal cord injury; SMD, standardized mean difference; tDCS, Transcranial Direct Current Stimulation; TENS, Transcutaneous Electrical Nerve Stimulation; UMN, Upper motor neuron; WBV, Whole-body vibration.

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1. Introduction

Spasticity is defined as ‘a disorder of sensorimotor control, resulting from an upper motor neuron (UMN) lesion, presenting as intermittent or sustained involuntary activation of muscles’ [1]. It is characterised by increased involuntary velocity-dependent tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyper-excitability of the stretch reflex [2]. Spasticity is common following neurological insults such as stroke, multiple sclerosis (MS), cerebral palsy (CP); or neurological trauma [such as brain injury, spinal cord injury (SCI)]. The exact incidence of spasticity is unknown [3], it is estimated to affect 38% of stroke survivors after 12 months [4]; experienced by 60–90% of persons with MS [5], 92% with primary lateral sclerosis and one in six people with traumatic brain injury (TBI) [3]. Despite the burden of care and significant economic implications, there is limited data on health and/or social costs or resources needed to care for people with spasticity [3,6,7]. The direct costs for stroke-survivors with spasticity, is almost four times higher than their counterparts without spasticity [7].

The clinical presentation of spasticity varies depending on the type of injury and associated with a range of symptoms and signs related to upper motor neuron (UMN) syndrome. The primary feature of spasticity is hyper-excitability of muscle stretch reflexes [2], which results in stiffness and abnormal posturing of the limb due to net imbalance of forces between agonist and antagonist muscles affecting static joint position and dynamic limb movement [8,9]. This results in abnormal motor control and dysregulation of voluntary movement, and presents as increased resistance offered by muscles to passive stretching (lengthening) [10]. Persons with spasticity can present with various combinations of signs, such as: clonus, clasp-knife phenomenon, hyperreflexia, ‘Babinski’ sign, spastic dystonia, flexor and extensor spasms, etc. [10,11]. Spasticity may also have positive effects. Some patients may rely on spasticity to maintain function of their non-functional limb. For example, a spastic weak limb may allow weight bearing for transfers [12]. Spasticity can be responsible of focal impairment (affecting a localised part of a limb), segmental, or generalised [affecting more than one part of a limb(s)] [13].

Physical impairments from spasticity [restricted joint range of movement (ROM), loss of dexterity, abnormal limb posture] can lead to progressive functional limitation [mobility, transfers, activities of daily living (ADLs)] – these impact carer burden and quality of life (QoL) [14,15]. Spasticity can often be associated with pain and other secondary complications (pressure areas, spasms, contractures) [14–16]. Further, other condition-related impairments such as fatigue, cognitive deficits also impact patient function. Many surgical/orthopaedic (such as lengthening procedures, tendon transfers, tenotomy, neurectomies, rhizotomy, peripheral neurotomy, etc.), pharmacological (such as baclofen, tizanidine, dantrolene, benzodiazepines, gabapentin, nabiximols, botulinum toxin) and other therapeutic interventions are used to manage spasticity in clinical setting, either individually or in combination [17–20]. Pharmacological agents can be associated with systemic side-effects (drowsiness, cognitive impairment) [17,20]. Neurosurgical procedures are considered for severe spasticity following the failure of pharmacological and/or non-pharmacological management [21]. Stand-alone pharmacological and surgical management of spasticity is not recommended, treatments are used in combination with other therapeutic modalities, encompassing an interdisciplinary rehabilitation approach [12,21].

In recent years, a range of non-pharmacological interventions has been used to manage spasticity. These include: physical interventions (stretching, passive movements); transcutaneous electric nerve stimulation (TENS); transcranial direct current

stimulation (tDCS); shock wave; vibratory stimulation (whole-body vibration); electromyography biofeedback; repetitive transcranial magnetic stimulation (TMS); therapeutic ultrasound; acupuncture; orthotics (splints, casts), thermotherapy, cryotherapy and others [14,15,22–30]. Various individual systematic reviews evaluate the effectiveness of these interventions, for example, physical activity [22,28], neuromuscular electrostimulation [29,30], acupuncture [24,26,31]. These reviews, however, vary in quality, scope and methodology, and at times report diverse findings. A systematic review of “systematic reviews” is a new approach to assemble current evidence across the same or very similar interventions, to provide synthesis of treatment effect in a much broader concept. The aim is to comprehensively synthesise evidence to establish benefit and harm associated with the interventions to guide treating clinicians [32,33]. This review, therefore, systematically evaluates evidence from published systematic reviews of clinical trials to determine effectiveness for a range of non-pharmacological modalities for spasticity in people with various neurological conditions.

2. Method

A comprehensive search of prominent health-science databases: Cochrane Library database (including DARE), MEDLINE, CINAHL, EMBASE and PubMed was undertaken till 15th June 2017 for systematic reviews evaluating non-pharmacological interventions currently used in management of spasticity. The search strategy included combinations of multiple search terms for two themes: spasticity and interventions (non-pharmacological) (Appendix 1). Manual search of reference lists of potential articles and most relevant journals for additional references were conducted. Authors and known experts in the field for further information were contacted. Further, search of grey literature conducted using different Internet search engines and websites: such as System for Information on Grey Literature in Europe; New York Academy of Medicine Grey Literature Collection, National Quality Measures Clearinghouse and Google Scholar. In addition, various healthcare institutions; and governmental and non-governmental organisations associated with management of different neurological conditions specific to spasticity were explored.

The inclusion criteria were: systematic reviews/meta-analyses that evaluated and defined non-pharmacological interventions (uni- and/or multi-disciplinary) aimed at reducing spasticity; reported a systematic electronic search of literature for a defined period; reviews conducted in adult population (≥ 18 years) and published in English. Also, systematic review/meta-analysis evaluating non-pharmacological interventions after concomitant pharmacological/surgical interventions were included. The exclusion criteria included: reviews evaluating pharmacological, surgical intervention or diagnostic procedures, non-English reviews, theses, narrative reviews and reviews listed only in conference proceedings.

2.1. Study selection and data extraction

Based on selection criteria two authors (BA, FK) independently screened and shortlisted all abstracts and titles of reviews identified by the search strategy. Both authors evaluated each study abstract from the searched list independently, and full text of all potential articles was obtained for assessment to determine whether the article met the inclusion/exclusion criteria. Any disagreement regarding the possible inclusion/exclusion of any individual study was resolved with the discussion with the third Author (DB) and by a final group consensus. Standard pro-forma was used for data extraction from all reviews, which included:

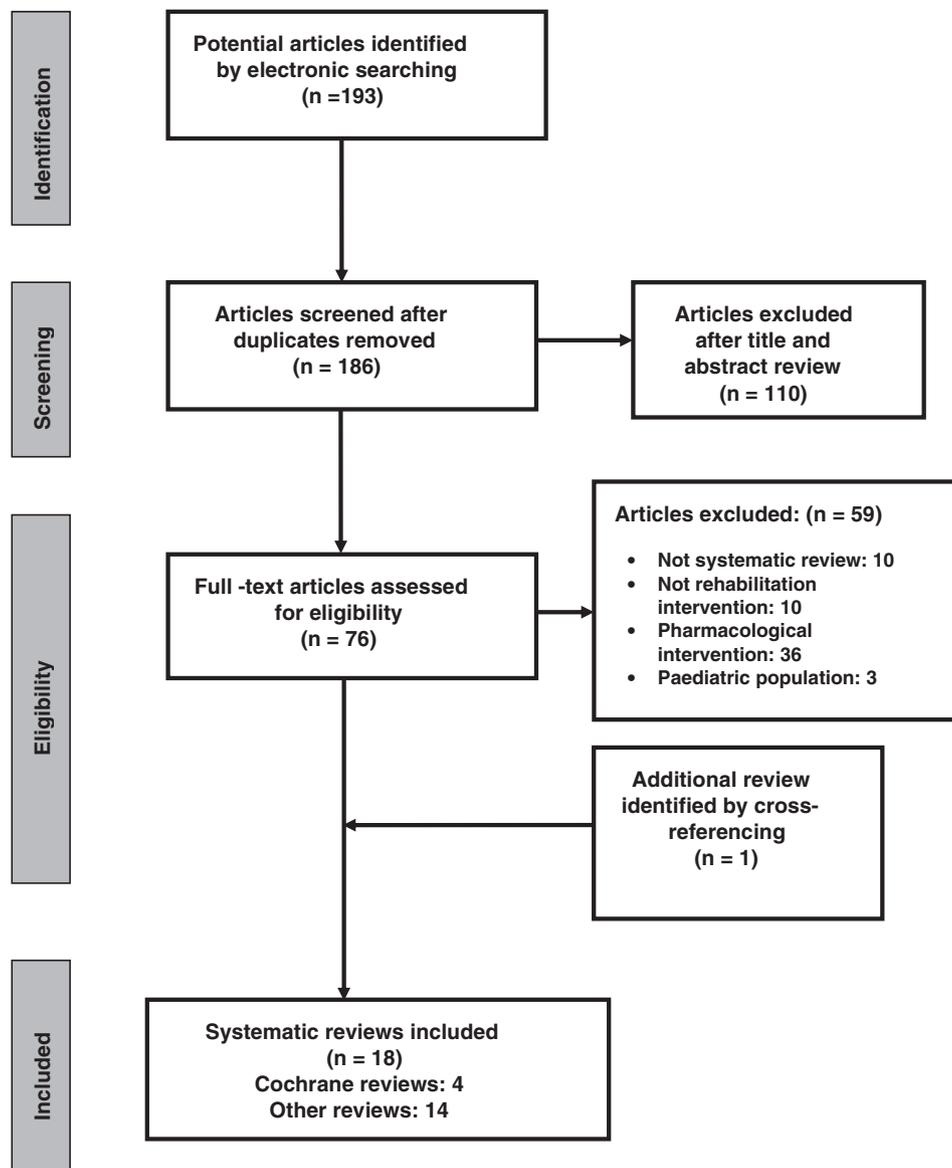


Fig. 1. PRISMA flow diagram showing selection of reviews.

publication and search date, objectives, characteristics of included studies and study subjects, intervention, findings and limitations. Any discrepancies were resolved by all authors re-reviewing the study.

2.2. Assessment of methodological quality of included studies

The methodological quality of included reviews was assessed using Assessment of Multiple Systematic Reviews (AMSTAR) appraisal tool by two reviewers (BA, FA) independently [34]. The AMSTAR, an 11-question tool (Appendix 2), is widely used in literature and has acceptable inter-rater agreement, construct validity and feasibility [35]. In addition, the Grade of Recommendation, Assessment, Development and Evaluation (GRADE) tool was used to assess quality of evidence for each type of intervention on 4-point scale (high, moderate, low and very low quality) [36]. Any discrepancies were resolved by a final consensus amongst all authors.

3. Results

The searches identified 193 published reviews evaluating non-pharmacological interventions currently used in management of

spasticity in different conditions. After screening the titles and removal of duplicates, 76 reviews met abstract inclusion criteria and were selected for closer scrutiny. Full texts of these articles were retrieved and both reviewers performed the final selection. One review that met the inclusion criteria was identified from bibliographies of relevant articles. Overall 18 systematic review/meta-analyses: 4 published in Cochrane Library database and 14 published in other academic journals, were included. These reviews were conducted in various neurological cohorts: 6 in stroke, one each in MS, brain injury and SCI; and 9 in mixed or other neurological cohorts. A PRISMA of the study selection process is provided in Fig. 1.

3.1. Quality of the systematic reviews

Table 1 provides the results of the AMSTAR quality assessment. There was marked heterogeneity amongst the included reviews in terms of methodological quality and risk of bias assessment methods. The kappa level of agreement between authors for AMSTAR assessment was 0.86. The overall mean AMSTAR methodological quality score for included systematic reviews

Table 1
Quality assessment (AMSTAR) of included systematic reviews.

Author year	AMSTAR Criteria ^a											
	1	2	3	4	5	6	7	8	9	10	11	Total
Stroke												
Cai et al., 2017 [24]	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	9
Lim et al., 2015 [26]	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	9
Park et al., 2014 [31]	N	Y	Y	N	N	Y	Y	Y	Y	N	N	7
Demetrios et al., 2015 [15]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Elsner et al., 2016 [25]	N	Y	Y	N	N	Y	Y	Y	Y	N	N	6
Stein et al., 2015 [30]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	10
MS												
Amatya et al., 2013 [14]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Brain injury												
Lee et al., 2014 [38]	N	Y	Y	N	N	Y	N	N	Y	Y	N	5
SCI												
Sadeghi & Sawatzky 2014 [39]	N	Y	Y	N	N	Y	Y	Y	N	N	N	5
Mixed Neurological Conditions												
Harvey et al., 2017 [40]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Katalinic et al., 2011 [41]	Y	Y	Y	Y	UA	Y	Y	Y	Y	Y	N	10
Bovend'Eerd et al., 2008 [22]	N	Y	Y	N	N	Y	Y	Y	Y	N	N	6
Prabhu et al., 2003 [28]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Huang et al., 2017 [42]	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	7
Intiso et al., 2016 [43]	N	Y	Y	N	N	Y	Y	Y	Y	Y	N	7
Korzhova et al., 2016 [27]	N	Y	N	N	N	Y	N	N	Y	N	N	3
Mills & Dossa 2016 [37]	N	Y	Y	N	N	N	Y	UA	N	N	N	3
Kinnear et al., 2015 [23]	UA	Y	Y	Y	N	Y	Y	Y	Y	Y	N	9

Y=Yes, criteria met (1 point); N=No, criteria not met (0 points); UA=unable to answer (0 points); NA=Not Applicable (0 points); MS=Multiple sclerosis; SCI=Spinal cord injury.

^a Assessment of Multiple Systematic Reviews (AMSTAR) criteria [34], please refer to Appendix 2.

was 7.6 (standard deviation: 2.4) and ranged from 3–10 out of 11. The quality of the included systematic reviews was mixed: 2 reviews were of low quality (i.e. AMSTAR scores between 0–4), 7 moderate quality (5–8), and 9 of high quality (9–11).

All reviews except one performed comprehensive literature search of medical science databases, however, only half of the reviews included a grey literature search. Majority of the included reviews, except Cochrane and related reviews had published *a priori* protocols or provided a list of excluded studies. All reviews, except two, assessed the scientific quality of the included primary studies using validated tools: ten used Cochrane Risk of Bias Tool, 4 used PEDro. Although 6 reviews provided their funding sources, none of the reviewers addressed the potential competing interests of authors of the primary studies (Table 1).

3.2. Evidence synthesis of non-pharmacological interventions

The existing best-evidence synthesis for non-pharmacological interventions for the management of spasticity in different neurological conditions are summarised below and in Table 2.

3.2.1. Stroke

Six reviews investigated effects of non-pharmacological interventions on spasticity in stroke survivors. Three reviews evaluated acupuncture (including electro-acupuncture) [24,26,31], two electrical stimulation [25,30] and one MD rehabilitation after BoNT injections [15].

The findings on effectiveness of acupuncture for spasticity in stroke survivors were mixed. One review reported electro-acupuncture having a beneficial effect as an adjunct therapy with conventional routine care (pharmacological and rehabilitation) in reducing spasticity (both upper and lower limbs); improvement in overall motor function and activities of daily living [24]. Another meta-analysis showed both acupuncture or electro-acupuncture

significantly decreased wrist, knee, and elbow spasticity in stroke patients [26]. However, the third meta-analysis found no effect of acupuncture on improving clinical outcomes, including spasticity [31]. There was marked heterogeneity amongst the included studies in the three reviews, in terms of study quality, control, acupoints, and the patient population [26,31]. The studies included in all three systematic reviews had small sample sizes and were of 'low' quality methodologically. Further, the studies overlapped amongst the three reviews, and participants were restricted to Chinese population, making generalisability of results to other populations questionable [24].

Neuromuscular electrical stimulation provided with other interventions showed significant reduction in spasticity [standard mean difference (SMD) = -0.30, 95% confidence interval (95%CI) = -0.58 to -0.03], and increase in ROM when compared with control group [SMD = 2.87, 95%CI = 1.18–4.56] [30]. The findings, however, were based on small number of studies and participants [30]. Another meta-analysis reported no beneficial effect of transcranial direct current stimulation (tDCS) on improving spasticity after stroke [25].

Demetrios et al. assessed the effectiveness of MD rehabilitation, following BoNT and other focal intramuscular treatments in post-stroke spasticity [15]. The authors reviewed trials, which included: modified Constraint-induced Movement therapy (mCIMT), task practice therapy with cyclic Functional Electrical Stimulation (FES) and occupational, manual therapy with dynamic elbow extension splinting. There was "low quality" evidence for mCIMT improving spasticity and upper limb motor function and "very low quality" evidence for dynamic elbow splinting and OT for improving elbow ROM [15].

3.2.2. Multiple sclerosis

Despite availability of wide range of interventions to treat spasticity in MS, only one systematic review assessed the effectiveness of various non-pharmacological interventions [14]. The interventions evaluated include: physical activity programs (physiotherapy, structured exercise programs, sports climbing); transcranial magnetic stimulation [Intermittent Theta Burst Stimulation (iTBS), Repetitive Transcranial Magnetic Stimulation (rTMS)]; electromagnetic therapy (pulsed electromagnetic therapy; magnetic pulsing device), TENS; and Whole-Body Vibration. The reviewers found "low level" evidence for physical activity programs used in isolation or in combination with other interventions (pharmacological or non-pharmacological), and for magnetic stimulation (iTBS/rTMS) with or without adjuvant exercise therapy in improving spasticity in adults with MS [14]. There was no evidence for other interventions.

3.2.3. Brain injury

Lee et al., in a meta-analysis, assessed effects of extracorporeal shock wave therapy on reducing spasticity in persons with any type of brain injury [38]. They report positive effect of extracorporeal shock wave therapy immediately after the intervention (SMD = -0.792; 95%CI = -1.001 to -0.583) and after 4-week post intervention (SMD = -0.735; 95%CI = -0.951 to -0.519) [38]. The authors [38], however, suggest cautious interpretation of results due to challenges in reliable spasticity assessment methods, standardization of treatment protocols (including treatment intervals and intensities).

3.2.4. Spinal cord injury (SCI)

One systematic review evaluated effectiveness of whole-body vibration or focal vibration on spasticity in individuals with SCI [39]. The reviewers report some beneficial effects of both vibration therapies in spasticity reduction for a short

Table 2
Systematic reviews evaluating non-pharmacological interventions in management of spasticity in different neurological conditions.

Author and year	Intervention	No. of included studies	Total no. of participants	Main results/findings	Meta-analysis	Quality of evidence (GRADE) ^a
Stroke						
Cai et al., 2017 [24]	Electro-acupuncture	22 RCTs Search date: to September 2016	n = 1425	Moderate level evidence for electro-acupuncture combined with conventional routine care (pharmacological and rehabilitation) in reduction in UL & LL spasticity, improved overall motor function, ADLs	Yes	Moderate
Lim et al., 2015 [26]	Acupuncture	5 RCTs Search date: 30 July 2013	n = 291	Moderate level evidence for acupuncture or electro-acupuncture reduction in spasticity (wrist, knee, and elbow)	Yes	Low
Park et al., 2014 [31]	Acupuncture	8 RCTs Search date: 1990 to August 2009	n = 399	No evidence in reduction in spasticity	Yes	Low
Demetriou et al., 2015 [15]	Multidisciplinary rehabilitation	3 RCTs Search date: 10 October 2012	n = 91 following BoNT-A & other focal intramuscular treatments	Low level evidence for mCIMT improving UL spasticity & motor function in chronic stroke survivors up to six months Limited evidence for dynamic elbow splinting & OT reducing elbow ROM at 14 weeks No evidence for task practice therapy with cyclic FES in improving UL function at 12 weeks	No	Low
Elsner et al., 2016 [25]	tDCS	5 RCTs Search date: 6 January 2016	n = 315	Moderate to low level evidence for no effect of tDCS on improving UL spasticity. No evidence for long-term effect of tDCS on improving spasticity	No	Low
Stein et al., 2015 [30]	NMES	29 RCTs Search date: February 2015	n = 940	Moderate level evidence for NMES combined with other modalities in improving spasticity & joint ROM	Yes	Moderate
MS						
Amatya et al., 2013 [14]	Spasticity management interventions	9 RCTs Search date: from 1996 to June 2012	n = 341 MS	Low level evidence for physical activity programs used in isolation or in combination with other interventions (pharmacological or non-pharmacological); for repetitive magnetic stimulation with or without adjuvant exercise therapy in improving spasticity	No	Low
Brain injury						
Lee et al., 2014 [38]	Extracorporeal Shock Wave Therapy (ESWT)	5 RCTs, Search date: June 2013	n = 117 (80 = stroke, 37 = CP)	Low level evidence for ESWT in improving spasticity immediately after intervention & at four weeks post-intervention	Yes	Low
SCI						
Sadeghi & Sawatzky 2014 [39]	Vibration (WBV or FV)	10 trials (different design) Search date: up to March 2011	n = 195	Low level evidence for FV in a short-term spasticity reduction lasting 24 hrs and for WBV in a decrease in spasticity lasting for 6-8 days post-intervention	No	Low
Mixed Neurological Conditions						
Harvey et al., 2017 [40]	Stretching	7 RCTs Search date: November 2015	n = 159	Inconclusive evidence in the short- or long-term beneficial effect on spasticity in people with neurological conditions	No	Low
Katalinic et al., 2011 [41]	Stretching	25 RCTs Search date: up to June 2010	n = 721 with neurological conditions	No evidence for beneficial effect of stretching on spasticity	Yes	Low

Table 2 (Continued)

Author and year	Intervention	No. of included studies	Total no. of participants	Main results/findings	Meta-analysis	Quality of evidence (GRADE) ^a
Bovend'Eerd et al., 2008 [22]	Stretching	21 trials (including 10 RCTs) Search date: January 2007	<i>n</i> = 428 (322 = stroke, 46 = MS, 27 = SCI, 33 = other)	Inconclusive evidence for spasticity	No	Low
Prabhu et al., 2003 [28]	Passive movement	2 RCT Search date: 21 November 2013	<i>n</i> = 122	Inconclusive evidence for passive movement for treatment of spasticity	No	Very Low
Huang et al., 2017 [42]	WBV	9 RCTs Search date: up to August 2015	<i>n</i> = 266 (4 stroke, 3 CP, 1 MS, 1 spinocerebellar ataxia)	Limited evidence on reducing LL spasticity in persons with CP Inconclusive evidence in other neurological conditions	No	Low
Intiso et al., 2016 [43]	ES	15 RCTs Search date: January 1966 to January 2016	<i>n</i> = 504	Moderate level evidence for ES as an adjunctive therapy to BoNT-A	Yes	Low
Korzhova et al., 2016 [27]	TMS	6 RCTs (overall 26 RCTs) Search date: 1966 to March 2006	<i>n</i> = 149	No evidence for TMS spasticity in stroke patients Limited evidence for TMS on improved spasticity in SCI	Yes	Low
Mills & Dossa 2016 [37]	TENS	14 RCTs (8 stroke, 3 SCI, 2 MS, 1 mixed) Search date: up July 2015	<i>n</i> = 544	Limited evidence for short-term improvement for different neurological conditions including stroke, SCI, MS	No	Low
Kinnear et al., 2015 [23]	Rehabilitation program	11 RCTs Search date: 2000 to October 2013	<i>n</i> = 234	Moderate level evidence that combination of stretch therapies and BoNT-A are more effective than the use of BoNT-A alone Limited evidence for electrical stimulation, constraint-induced movement therapy on improved spasticity	Yes	Low

ADL = activities of daily living; BoNT-A = Botulinum toxin-A; CP = cerebral palsy; ES = electrical stimulation; FES = functional electrical stimulation; FV = focal vibration; LL = lower limb; MS = multiple sclerosis; mCIMT = modified constraint-induced movement therapy; NMES = neuromuscular electric stimulation; OT = occupational therapy; PT = physical therapy; RCT = randomised controlled trial; ROM = range of motion; SCI = spinal cord injury; TENS: transcutaneous electrical nerve stimulation, tDCS = transcranial direct current stimulation; UL = upper limb; WBV = whole body vibration.

^a GRADE = Grade of Recommendation, Assessment, Development and Evaluation Working Group grades of evidence: high quality: further research is very unlikely to change our confidence in the estimate of effect; moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; very low quality: we are very uncertain about the estimate.

period. However, these findings were tentative due to lack of robust studies and there were no recommendations using vibration to guide clinicians [39].

3.2.5. Mixed neurological conditions

Stretching is commonly used as therapeutic modalities for spasticity and prevention of contractures. Three systematic reviews [22,40,41] evaluated effects of stretching on spasticity (and contractures) in different neurological cohorts. All three reviews found inconclusive results with no evidence for short- or long-term effects of stretch on spasticity. Prabhu et al. investigated the effectiveness of passive movements in persons with contractures and evaluated spasticity as a primary outcome. There was no evidence to support use of passive stretch for reduction in spasticity [28]. Another review examined effects of Whole-Body Vibration (WVB) on spasticity amongst people with various neurological conditions and found no evidence to support WVB for spasticity [42].

Three reviews evaluated different forms of electrical stimulation [27,37,43] for spasticity. Intiso et al. investigated effectiveness of electrical stimulation as an adjunct to BoNT-A in reducing spasticity in adults [43]. They report that electrical stimulation reduces spasticity, and may boost action of BoNT-A therapy. Korzhova et al. evaluated rTMS in treatment of spasticity with some beneficial effect in patients with SCI, but not in stroke patients [27]. Another review summarized the effect of TENS for management of limb spasticity. Although “some” evidence for TENS in improving spasticity was reported, evidence was insufficient to support TENS as an adjunct therapy to active therapies (such as BoNT-A, physical therapy, etc.) [27,37,43].

4. Discussion

This review systematically analyses evidence from published systematic reviews to date for the effectiveness of non-pharmacological interventions in the management of spasticity in different neurological conditions. Overall, 18 systematic reviews/meta-analyses were evaluated for outcome data specific to spasticity. The findings indicate that, though a broad range of non-pharmacological approaches are trialled for spasticity in different neurological cohorts, high-quality evidence for effectiveness of these modalities is limited. The overall findings of this review suggest:

- **Moderate quality evidence for:**
 - electro-acupuncture combined with conventional routine care (pharmacological/rehabilitation) in reducing spasticity, improvement in overall motor function and ADLs in persons with stroke,
 - Neuromuscular electric stimulation combined with other interventions in improvement in spasticity and joint ROM in stroke survivors;
- **Low quality evidence for:**
 - rehabilitation programs targeting spasticity (such as mCIMT; stretching, dynamic elbow splinting and OT, electrical stimulations, etc.) in stroke and other neurological conditions,
 - extracorporeal shock wave therapy for limited improvement in spasticity immediately after and at four weeks post-intervention in brain injury,
 - electrical stimulation therapy: tDCS in stroke patient; TMS and TENS for other neurological conditions,
 - physical activity programs and repetitive magnetic stimulation in MS,
 - vibration therapy for SCI and other neurological conditions,
 - stretching for neurological conditions;

- **Very low evidence for:** passive movement in neurological conditions.

The methodological quality and evidence in the systematic reviews varied as shown by the range of AMSTAR scores. Overall, half the included reviews were of high methodological quality. Due to variation in standard of reporting, non-Cochrane reviews scored significantly lower compared with those published in the Cochrane Library. None of the non-Cochrane reviews published protocols nor provided explicit list of excluded studies, therefore, none fulfilled the first and fifth criterions of the AMSTAR tool (Appendix 2). Surprisingly, none met the AMSTAR criterion 11, even though the reviewers declared their own conflicts of interest, none systematically reported author conflict of interest for included trials. Majority of the included reviews used Cochrane risk of bias tool, followed by PEDro tools to evaluate methodological quality of included studies. In addition, the terminology and definitions used for “spasticity” were inconsistent amongst the reviews, and many used multiple terms such as “hypertonicity”, “tone”, “dystonia” and/or “spasticity”. Three reviews on stretching and passive movements evaluated interventions aiming to reduce and prevent “contracture”, and included spasticity as one of the outcome measures [28,40,41].

Spasticity is a complex disorder and has significant clinical importance. Evaluating and treating the patient with spasticity can be difficult, and what, which intervention, when to provide best clinical modality and in which dose/intensity have been debated [12]. This is consistent with the findings of this review, indicating array of treatment choices for the clinicians. There are still significant challenges in applying the existing evidence in clinical practice, mainly due to interaction of spasticity with other components of the UMN syndrome and heterogeneous patient population with varied and unpredictable clinical presentations, and lack of evidence for ideal patient selection criteria for spasticity management [15]. There is a need for comprehensive MD neuro-rehabilitation programs to prospectively specify treatment goals (including patients' perspectives) and rationalize the possible benefits of treatment with the risks [12,20,44]. The goals aim to improve patient function and participation with emphasis on patient education and self-management [14,15]. Despite, reported beneficial effects of some of the non-pharmacological interventions [14,45], optimal timing, type, duration and intensity of therapy remain poorly defined. At times, many interventions are difficult to characterise and standardise. In general comprehensive spasticity management programs should comprise a series of individualized and goal-oriented therapies tailored for specific patient needs [14,33,46].

Spasticity is difficult to quantify and the various current tools for assessment can be ambiguous in terms of what is being treated and measured [47,48]. Commonly used generic scales (such as Functional Independence Measure, Barthel Index) are not sensitive enough to measure the effects of treatment on spasticity [20]. The common measures used are: Ashworth Scale [49], the Modified Ashworth Scale [50,51] and Tardieu scales [52], but these ordinal scales quantify the resistance of spastic muscles to passive movement, as perceived by the examiner [53,54]. Many argue that these scales do not provide sufficient information and the reliability and validity of these has been questioned in clinical practice [54–56]. Other condition-specific measures with similar limitations include: Multiple Sclerosis Spasticity Scale (MSSS-88) [5] and Triple Spasticity Scale (TSS) for stroke. Some of the new instrumented techniques for clinical gait analysis, powered systems can be useful in assessing spasticity with greater reliability and precision of measurement [57].

With varying patterns and problems from spasticity, treatment should be initiated after rigorous assessment (intensity, distribu-

tion and impact on patient function) [20]. Expert consensus suggests that interventions should be considered when level of spasticity interferes with patient's daily activities, by setting up patient-centred goals collaboratively with patients, their carers' and the treating team [14,15,20]. The existing clinical practice guidelines and consensus statements on spasticity management recommend an interdisciplinary holistic model of care [58–60], but uptake of this integrated approach is far from universal. Further, these recommendations are based on expert opinion rather than formal research evidence [15]. Therefore, there is need for evidence-based approach employed in this review which allows findings from more than one systematic review to be compared and contrasted, thereby providing a comprehensive summary of evidence at a variety of levels, including the combination of different interventions, or the provision of summary of evidence on different outcomes or problems [32].

4.1. Study limitations

This review has several limitations in terms of methodology and completeness of the literature retrieval. First, the search encompassed only published literature in specific searched health-science databases, which may have missed other possible relevant articles from other sources. Second, only bibliography of relevant reviews were scrutinised, which may introduce a reference bias. However, most prominent databases in medical literature and grey literature were searched using comprehensive search terms to capture the widest possible selection of relevant reviews. Third, there are certain limitations of the tools used to assess the methodology (AMSTAR) and quality of evidence (GRADE) for included reviews. However, these are widely used validated tools, and appraising the tools was beyond the scope of this review. Two included reviews were from our own research group (both from the Cochrane Library). The independence of assessors' assessments therefore could not be guaranteed. However, the appraisals of these two reviews are consistent with other similar included reviews and are valid. It was not possible to evaluate adverse events related to the interventions, as reporting in the included reviews was often incomplete and/or inconsistent. None of the trials reported associated costs or economic-benefit of interventions.

5. Conclusion

Spasticity management continues to be challenging. There is increasing awareness of the contribution of non-pharmacological interventions in early and long-term spasticity care. Despite the range of non-pharmacological interventions in use, evidence for many is still unclear. Although, there are gaps in literature, the findings from this review suggest an integrated MD goal-centered management approach is essential to providing a long-term, comprehensive care for spasticity. More research is needed to build evidence for types of non-pharmacological therapy components, modalities, duration and setting of therapy. Future research should focus on interventions that can be integrated into MD programs to develop effective care-pathways and long-term functional outcomes; to engage, educate, and empower patients.

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Disclosure of interest

The authors declare that they have no competing interest.

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Appendix 1. Keywords used for search

Theme 1. Spasticity

spasm, muscle spasticity, spasticity, muscular spasm, spastic, spastic paretic syndrome, spasticism, hypertonia

Theme 2. Non-pharmacological intervention

rehabilitation, ambulatory care, patient care team, multidisciplinary/integrated team, physical therapy modalities, physiotherapy, exercise therapy, massage, stretching, passive movement, stretching, static positioning; occupational therapy, acupuncture, social work, orthotics, casting, neurodevelopmental treatment, hydro/pool therapy, thermotherapy, assistive technology device, electromagnetic therapy, nerve stimulation, vibration therapy, cryotherapy, shock waves, therapeutic ultrasound, psychological and educational interventions, vocational rehabilitation

Appendix 2. Table 1 Assessment of Multiple Systematic Reviews (AMSTAR) criteria

Was an "a priori" design provided?
Was there duplicate study selection and data extraction?
Was a comprehensive literature search performed?
Was the status of publication (i.e. grey literature) used as an inclusion criterion?
Was a list of studies (included and excluded) provided?
Were the characteristics of the included studies provided?
Was the scientific quality of the included studies assessed and documented?
Was the scientific quality of the included studies used appropriately in formulating conclusions?
Were the methods used to combine the findings of studies appropriate?
Was the likelihood of publication bias assessed?
Was the conflict of interest stated?

Each AMSTAR criterion is scored as:

Y = Yes, criteria met

N = No, criteria not met

UA = unable to answer

NA = Not Applicable

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