Effectiveness of Stretch for the Treatment and Prevention of Contractures in People With Neurological Conditions: A Systematic Review

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Background. Contractures are a disabling complication of neurological conditions that are commonly managed with stretch.

Objective. The purpose of this systematic review was to determine the effectiveness of stretch for the treatment and prevention of contractures. The review is part of a more-detailed Cochrane review. Only the results of the studies including patients with neurological conditions are reported here.

Data Sources. Electronic searches were conducted in June 2010 in the following computerized databases: Cochrane CENTRAL Register of Controlled Trials, Database of Abstracts of Reviews of Effects (DARE), Health Technology Assessment Database (HTA), MEDLINE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), EMBASE, SCI-EXPANDED, and Physiotherapy Evidence Database (PEDro).

Study Eligibility Criteria. The review included randomized controlled trials and controlled clinical trials of stretch applied for the purposes of treating or preventing contractures in people with neurological conditions.

Study Appraisal and Synthesis Methods. Two reviewers independently selected studies, extracted data, and assessed risk of bias. The primary outcome measures were joint mobility (range of motion) and quality of life. Secondary outcome measures were pain, spasticity, activity limitation, and participation restriction. Meta-analyses were conducted using random-effects models.

Results. Twenty-five studies met the inclusion criteria. These studies provide moderate-quality evidence that stretch has a small immediate effect on joint mobility (mean difference=3°, 95% confidence interval [CI]=0° to 5°) and high-quality evidence that stretch has little or no short-term or long-term effects on joint mobility (mean difference=1° and 0°, respectively, 95% CI=0° to 3° and −2° to 2°, respectively). There is little or no effect of stretch on pain, spasticity, and activity limitation.

Limitations. No studies were retrieved that investigated the effects of stretch for longer than 6 months.

Conclusion. Regular stretch does not produce clinically important changes in joint mobility, pain, spasticity, or activity limitation in people with neurological conditions.

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Contractures are a common complication of neurological conditions such as stroke, spinal cord injury, traumatic brain injury, and cerebral palsy.[1] They are characterized by a reduction in joint mobility and an increase in resistance to passive joint movement.[1,2] Contractures are due to neural and non-neural factors, including spasticity and structural changes in soft tissues.[3] Spasticity is characterized by an increased resistance to passive joint movement due to involuntary muscle contraction. Contractures can result in deformities, pain, and skin breakdown and may restrict activity and participation.[2,4–7] For these reasons, the treatment and prevention of contractures are important goals of therapy for people with neurological conditions.

Stretch is widely used to treat and prevent contractures (as defined by the *International Classification of Functioning, Disability and Health*[8]).[*,9–13] Stretch can be self-administered, applied manually by therapists, or administered with positioning programs, splints, or serial casts. The duration of stretch varies depending on how it is applied. For example, stretch administered manually is applied for a few minutes a day, whereas stretch administered through serial casts is applied continuously for days or weeks at a time.

[*] See www.physiotherapyexercises.com for more than 100 examples of stretches typically prescribed by physical therapists.

Any stretch induces a transient increase in tissue extensibility. This increase is due to viscous deformation and quickly dissipates with the removal of the stretch.[14–18] Contracture management requires more-lasting changes in tissue extensibility. Evidence from animal studies suggests that contracture management can be achieved through repeated or sustained stretch (over days, weeks, or months). For example, 4 weeks of sustained stretch in cat soleus muscles results in tissue remodeling and specifically an increase in the number of sarcomeres in series.[19] No study on humans has investigated the effect of stretch on sarcomere numbers. However, many studies on humans have investigated the effects of stretch on joint mobility and range of motion.

This systematic review is part of a more-detailed Cochrane review investigating the effectiveness of stretch for the treatment and prevention of contractures in all types of participants, including those with contractures following trauma or disease processes.[20] The results of the studies including participants with neurological conditions are reported here. The purpose of this systematic review, therefore, was to determine the effectiveness of stretch for contracture management in people with neurological conditions. The primary objective was to determine whether stretch increases joint mobility or quality of life. The secondary objective was to determine the effects of stretch on pain, spasticity, activity limitation, and participation restriction.

Method

Data Sources

Computerized databases were originally searched in April 2009 for the Cochrane review and then updated in May and June 2010 for this publication. The included databases were: Cochrane CENTRAL Register of Controlled Trials, Database of Abstracts of Reviews of Effects (DARE), Health Technology Assessment Database (HTA; Wiley Interscience; May 2010), MEDLINE (OVID; 1950 to May 2010), Cumulative Index to Nursing and Allied Health Literature (CINAHL; EBSCOhost; 1982 to May 2010), EMBASE (OVID; 1980 to May 2010), SCI-EXPANDED (ISI Web of Knowledge; 1900 to May 2010), and Physiotherapy Evidence Database (PEDro; www.pedro.org.au; June 2010). The electronic searches were complemented with a search of clinical trial registers and of the reference lists of included studies and relevant systematic reviews (for full search strategies, see the Cochrane review[20]). Forward citation tracking of included studies also was used to search for additional studies using the ISI Web of Knowledge. Authors of included studies were contacted for additional studies and unpublished data where necessary and possible.

Study Eligibility Criteria

Studies were included if they were published or unpublished randomized controlled trials or controlled clinical trials that measured joint mobility (reported in any language). They could use parallel-group, within-subjects, or crossover designs. Participants could be of any age or either sex, provided they had existing contractures or were at risk of developing contractures. Only studies including participants with neurological conditions were eligible for this review.

Studies were included if stretch was compared with no stretch or with sham stretch. Studies with a cointervention (eg, botulinum toxin) were included if the cointervention was the same for the treatment and control groups. Stretch interventions could include sustained passive stretch, positioning, splinting, serial casting, or any other manual stretch

technique aimed at maintaining or increasing the mobility of any synovial joint. To be included, the stretch needed to sustain the soft tissues in a lengthened position for at least 20 seconds on more than one occasion. Studies were excluded if the intervention involved oscillating a joint through range. For example, studies of joint mobilization, joint manipulation, continuous passive motion, passive movements, and active movements were excluded. Studies were excluded where 2 types of stretch were compared with each other or where stretch was compared with an active intervention.

Study Appraisal and Synthesis Methods

Two authors independently extracted data and assessed the quality of the evidence using preconstructed forms. The following data were extracted: information about study design, inclusion and exclusion criteria, characteristics of the participants, details of the interventions, and results of the outcome measures. The risk of bias in each study was assessed using Cochrane Risk of Bias tables.[21] Each study was rated on 8 domains: sequence generation; allocation concealment; blinding of participants, therapists, and outcome assessors; incomplete data; selective outcome reporting; and other potential threats to validity. In addition, the pooled evidence about the effectiveness of stretch on joint mobility was rated according to GRADE on a 4-point scale (high, medium, low, and very low).[22–25] GRADE uses set criteria that take into account factors such as the consistency of results across studies, the precision of estimates, and the susceptibility to publication bias. Disagreements in ratings were resolved by discussion or, where necessary, arbitrated by the third author.

Measures of treatment effect were extracted for primary and secondary outcomes. The primary outcome measures were joint mobility (essential for inclusion) and quality of life. Torque-controlled measures of joint mobility were extracted in preference to all other joint mobility measures. If torque-controlled measures were not reported, passive joint mobility measures were given the next order of preference. If passive joint mobility measures were not reported, active joint mobility measures were extracted. The secondary outcomes of interest were pain (eg, visual analog scale scores), spasticity (eg, Tardieu scale or modified Ashworth scale scores), activity limitation (eg, Functional Independence Measure or Motor Assessment Scale scores), and participation restriction (eg, return to work). Measures of treatment effect were extracted for 3 time frames: immediate (ie, effects present less than 24 hours after the last stretch was ceased), short-term (ie, effects present between 24 hours and 1 week after the last stretch was ceased), and long-term (ie, effects present more than 1 week after the last stretch was ceased).

Analysis of covariance-adjusted between-group means and standard deviations were extracted in preference to between-group differences in change scores, and between-group differences in change scores were extracted in preference to between-group differences in final scores. If studies reported data as medians and interquartile ranges (IQRs), medians were used as a surrogate for means and standard deviations were estimated as 80% of the IQR. Differences in the data extracted by the 2 review authors were resolved by discussion and, when necessary, arbitrated by the third author. Study authors were contacted when there was incomplete reporting of data.

Meta-analysis using a random-effects model was considered when there were at least 2 clinically homogenous studies (studies that investigated the effect of similar interventions on similar populations and reported similar outcomes). Review Manager 5[26] was used for the primary data analysis. Data were pooled

The Bottom Line

What do we already know about this topic?

It is widely believed that regular stretch is effective for the treatment and prevention of contractures. Anecdotal evidence, single-case studies, case reports, and nonrandomized trials support the ongoing use of stretch.

What new information does this study offer?

This review of randomized trials shows that programs of stretch, as typically applied, have little or no effect on joint range of motion when applied for less than 7 months. The effects of longer-duration programs of stretch are not known.

If you're a patient, what might these findings mean for you?

People with contractures or who are at risk for contractures are unlikely to benefit from programs of stretch applied for less than 7 months.

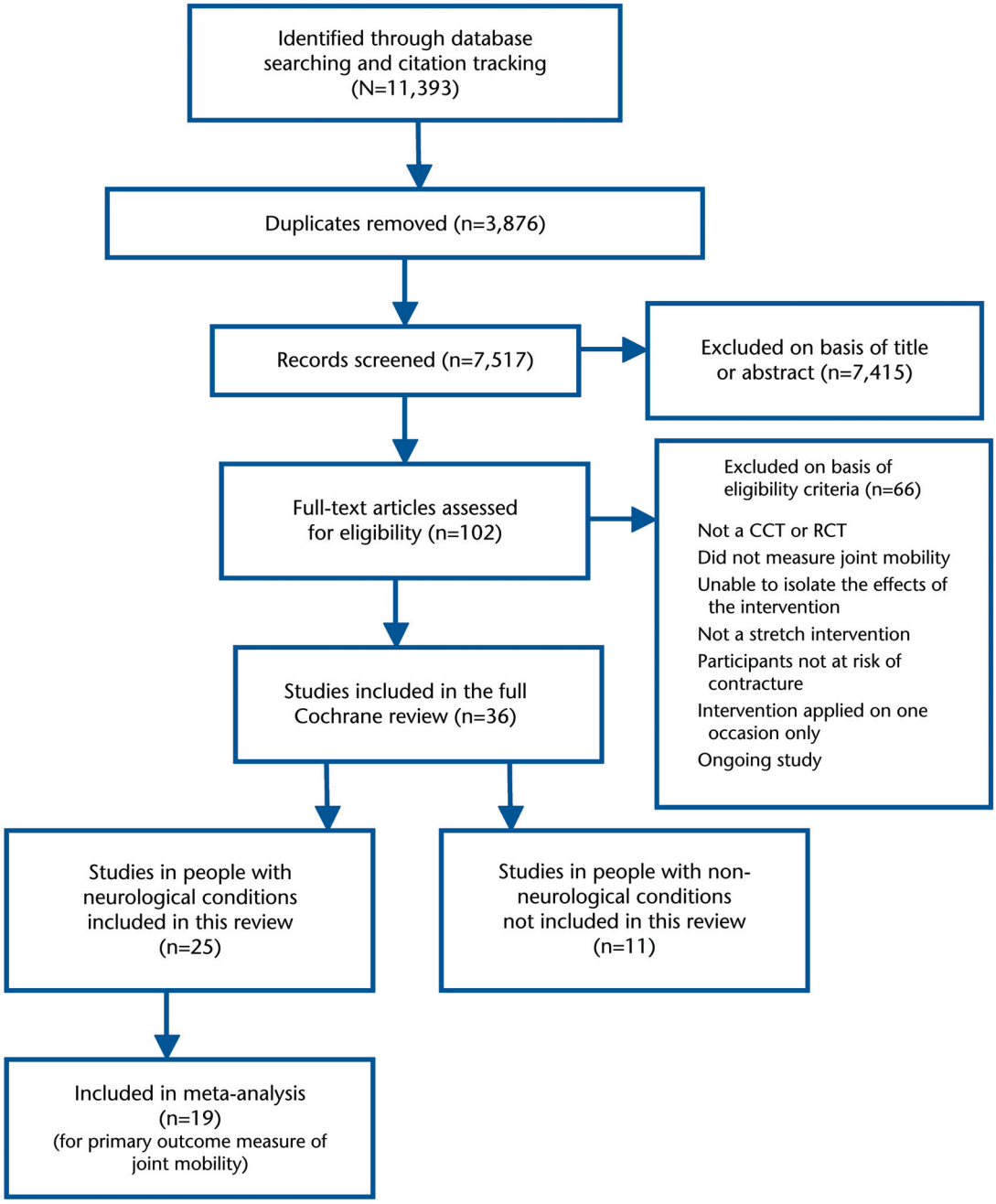


Figure 1.
Flow of studies through the review process. CCT=clinical controlled trial, RCT=randomized controlled trial.

only if the I^2 statistic (a measure of homogeneity) was less than 50%. If I^2 was greater than 50%, possible causes of heterogeneity were explored in sensitivity analyses. Individual studies were omitted one at a time, stratified by particular characteristics or, where appropriate, analyzed with meta-regression. The sensitivity analyses examined the effects of randomization (adequate versus inadequate sequence generation), concealed allocation (concealed versus nonconcealed allocation), assessor blinding (blinding versus no blinding), and completeness of data reporting (complete versus incomplete reporting of outcome data).

Results

Study Selection and Characteristics

The searches identified 11,393 references, of which 3,876 were dupli-

Table 1.
Details of Included Studies[a]

Study	Participants		Study Details			
	n	Details	Groups	Stretch Dosage	Design	Outcomes[b]
Stroke						
Ada et al,[28] 2005	Exp=18 Con=18	Adults with stroke	1. Two 30-min sessions of shoulder positioning + up to 10 min of shoulder exercises and routine upper-limb care 2. Up to 10 min of shoulder exercises and routine upper-limb care	2 × 30 min 5 d 4 wk	Randomized parallel group study	Maximum passive shoulder external rotation of the affected limb (°) Pain experienced during maximal external rotation (yes/no) Item 6 Motor Assessment Scale (limits: 0=worse; 6=better)
Burge et al,[30] 2008	Exp=31 Con=16	Adults with stroke	1. Wrist orthosis + conventional care 2. Conventional care	Not specified	Randomized parallel group study	Wrist ROM (Fugl-Meyer Assessment subscale) Pain (VAS) Modified Ashworth Scale
de Jong et al,[32] 2006	Exp=10 Con=9	Adults with stroke	1. Upper-limb positioning + conventional care 2. Conventional care	2 × 30 min 5 d 5–10 wk	Randomized parallel group study	Passive shoulder abduction (°) Pain (yes/no) Spasticity (Ashworth scale) Arm motor performance (Fugl-Meyer Assessment)
Dean et al,[33] 2000	Exp=14 Con=14	Adults with stroke	1. Three 20-min sessions of shoulder positioning + conventional care 2. Conventional care	3 × 20 min 5 d 6 wk	Randomized parallel group study	Passive shoulder external rotation (°) Pain at rest (VAS)
Gustafsson et al,[35] 2006	Exp=17 Con=17	Adults with stroke	1. Two 20-min sessions of shoulder positioning and a shoulder positioning program + conventional care 2. Conventional care	2 × 20 min Remainder of the day in a positioning program for an average of 30 d	Randomized parallel group study	Passive shoulder external rotation (°) Hemiplegic shoulder pain at rest over previous 24 h (VAS) Functional independence (Modified Barthel Index)
Horsley et al,[40] 2007	Exp=20 Con=20	Adults with stroke or stroke-like brain injury	1. Upper-limb stretch + usual care 2. Usual care	30 min 5 d 4 wk	Randomized parallel group study	Passive wrist extension (°) Pain at rest at the time of testing (VAS) Upper-limb activity (composite of 3 items of Motor Assessment Scale)
Lai et al,[42] 2009	Exp=15[c] Con=15[c]	Adults with stroke	1. Elbow extension splint + botulinum toxin and therapy 2. Botulinum toxin and therapy	6–8 h 7 d 14 wk	Randomized parallel group study	Maximal active ROM (elbow extension) Modified Ashworth Scale (extension score)
Lannin et al,[43] 2003	Exp=17 Con=11	Adults with stroke or brain injury	1. Palmar resting mitt splint + stretch 2. Stretch	12 h 7 d 4 wk	Randomized parallel group study	Passive wrist extension (°) Upper-limb pain (VAS) Upper-limb activity (composite of 3 items of Motor Assessment Scale)
Lannin et al,[44] 2007	Exp=21 Group 2=21 Con=21	Adults with stroke	1. Wrist extension splint 2. No splint	12 h 7 d 4 wk	Randomized parallel group study	Passive wrist extension (°) Pain (DASH–pain severity item) Spasticity angle (Tardieu scale) DASH

(Continued)

Table 1.
Continued

Study	Participants		Study Details			
	n	Details	Groups	Stretch Dosage	Design	Outcomes[b]
Sheehan et al,[50] 2006	Exp=6 Con=8	Adults with stroke	1. Resting wrist splint 2nd week to 7th week 2. Resting wrist splint 3rd week to 7th week	8 h 7 d 1 wk	Randomized parallel group study	Resistance (N) at 20° of extension
Turton and Britton,[51] 2005	Exp=14 Con=15	Adults with stroke	1. Two 30-min sessions of upper-limb positioning + usual care 2. Usual care	2 × 30 min 7 d 12 wk	Randomized parallel group study	Passive wrist extension of the affected arm (°)
Spinal cord injury						
Ben et al,[29] 2005	Exp=20 legs Con=20 legs	Adults with spinal cord injury	1. Weight-bearing and ankle stretch 2. Non–weight bearing and non-stretch	30 min 3 d 12 wk	Randomized within-subjects study	Passive ankle dorsiflexion at standardized torque (°)
Crowe et al,[31] 2000	Exp=18 Con=21	Adults with spinal cord injury	1. Shoulder positioning + conventional care 2. Conventional care	45 min 5 d 2–16 wk	Randomized parallel group study	Passive shoulder abduction, right arm (°) Pain during preceding 24 h, right shoulder (VAS) Functional Independence Measure
DiPasquale-Lehnerz,[34] 1994	Exp=7 Con=6	Adults with spinal cord injury	1. Positional orthosis (hand) + rehabilitation 2. Rehabilitation	8 h 7 d 12 wk	Randomized parallel group study	Passive metacarpophalangeal joint extension Jebsen Hand Test subitem simulated feeding (s)
Harvey et al,[36] 2000	Exp=14 legs Con=14 legs	Adults with spinal cord injury	1. Ankle stretch 2. No ankle stretch	30 min 5–7 d 4 wk	Randomized within-subjects study	Ankle angle at 10 N·m of torque with the knee extended (°)
Harvey et al,[37] 2003	Exp=16 legs Con=16 legs	Adults with spinal cord injury	1. Hamstring muscle stretch 2. No hamstring muscle stretch	30 min 5 d 4 wk	Randomized within-subjects study	Hip flexion at 30 N·m of torque (°)
Brain injury						
Hill,[39] 1994	Exp=8[c] Con=7[c]	Adults with brain injury	1. Serial casting of the elbow or wrist followed by therapy 2. Therapy followed by serial casting of the elbow or wrist	24 h 7 d 4.3 wk	Randomized cross-over study	Unidirectional joint passive ROM (°) Joint angle at which stretch reflex elicited (°) Observation of performance of functional tasks
Moseley,[47] 1997	Exp=5 Con=5	Adults with traumatic brain injury	1. Short-leg cast[d] 2. No cast[d]	24 h 7 d	Randomized cross-over study	Passive ankle dorsiflexion (°)
Mixed						
Harvey et al,[38] 2006	Exp=30 thumbs Con=30 thumbs	Adults with stroke, spinal cord injury, or traumatic brain injury	1. Thumb splint 2. No splint	8 h 7 d 12 wk	Randomized within-subjects and parallel group study	Palmar abduction of the thumb carpometacarpal joint (°) Effect of the splinting regimen on self-selected goals (Canadian Outcome Performance Measure)

(Continued)

Table 1.
Continued

Study	Participants		Study Details			
	n	Details	Groups	Stretch Dosage	Design	Outcomes[b]
Cerebral palsy						
Ackman et al,[27] 2005	Exp=13 Con=12	Children with cerebral palsy	1. Botulinum toxin + cast 2. Botulinum toxin	24 h 7 d 9 wk	Randomized parallel group study	Passive ankle dorsiflexion with knee extended (°) Triceps surae muscle spasticity (Ashworth scale)
Law et al,[45] 1991	Exp=19[c] Con=18[c]	Children with cerebral palsy	1. Intensive NDT + short-arm cast 2. Intensive NDT	4 h 7 d 26 wk	Randomized parallel group study	Wrist ROM (scale not reported) Peabody Fine Motor Scale
McNee et al,[46] 2007	Exp=5 Con=4	Children with cerebral palsy	1. Short-leg cast[d] 2. No cast[d]	24 h 7 d 3–4 wk	Randomized cross-over study	Passive ankle dorsiflexion with knee extended (°) Normalcy Index for walking
Charcot-Marie-Tooth disease						
Refshauge et al,[48] 2006	Exp=14 legs Con=14 legs	Children + young adults with Charcot-Marie-Tooth disease	1. Night splint (ankle)[d] 2. No night splint[d]	4–9 h 7 d 6 wk	Randomized within-subjects cross-over study	Passive ankle dorsiflexion (°)
Rose et al,[49] 2010	Exp=15 Con=15	Children + young adults with Charcot-Marie-Tooth disease	1. Below-knee night cast + ankle stretch 2. No intervention	Weeks 1–4: 8 h 7 d 4 wk Weeks 5–8 3 × 2 min 7 d 4 wk	Randomized parallel group study	Ankle dorsiflexion (°) (lunge test) Preferred walking speed (m/s)
Duchenne muscular dystrophy						
Hyde et al,[41] 2000	Exp=15 Con=12	Children with Duchenne muscular dystrophy	1. Below-knee night splint + passive stretch 2. Passive stretch	Night splint time not reported	Randomized parallel group study	Achilles tendon contracture Motor Ability Scale

[a] Exp=experimental group, Con=control group, ROM=range of motion, VAS=visual analog scale, DASH=Disabilities of the Arm, Shoulder, and Hand Outcome Measure, NDT=neurodevelopmental therapy.
[b] Outcomes listed in the table are the subset of study outcomes that were within the scope of this review.
[c] Number of participants analyzed by the study authors (these numbers do not include dropouts). Authors did not report the size of the group allocations at baseline.
[d] Details of the first cross-over period only.

Table 2.
Methodological Quality Summary (Risk of Bias)[a]

Study	Adequate Sequence Generation?	Allocation Concealment?	Blinding (Participants)?	Blinding (Therapists)?	Blinding (Assessors)?	Incomplete Outcome Data Addressed?	Free of Selective Reporting?	Free of Other Bias?
Ackman et al,[27] 2005	?	?	N	N	Y	Y	Y	N
Ada et al,[28] 2005	Y	Y	N	N	Y	Y	Y	Y
Ben et al,[29] 2005	Y	Y	N	N	Y	Y	Y	Y
Burge et al,[30] 2008	Y	Y	N	N	Y	Y	N	Y
Crowe et al,[31] 2000	Y	Y	N	N	Y	?	N	N
de Jong et al,[32] 2006	Y	Y	N	N	Y	N	N	N
Dean et al,[33] 2000	Y	Y	N	N	Y	N	Y	Y
DiPasquale-Lehnerz,[34] 1994	?	?	N	N	?	N	N	Y
Gustafsson et al,[35] 2006	Y	Y	N	N	N	Y	Y	?
Harvey et al,[36] 2000	Y	Y	N	N	Y	Y	Y	Y
Harvey et al,[37] 2003	Y	Y	N	N	Y	Y	Y	Y
Harvey et al,[38] 2006	Y	Y	N	N	Y	Y	?	Y
Hill,[39] 1994	N	N	N	N	Y	N	N	Y
Horsley et al,[40] 2007	Y	Y	N	N	Y	Y	Y	Y
Hyde et al,[41] 2000	Y	?	N	N	Y	N	N	Y
Lai et al,[42] 2009	?	?	N	N	?	N	Y	?
Lannin et al,[43] 2003	Y	Y	N	N	Y	Y	Y	Y
Lannin et al,[44] 2007	Y	Y	N	N	Y	Y	Y	Y
Law et al,[45] 1991	?	?	N	N	Y	Y	N	N
McNee et al,[46] 2007	?	?	N	N	?	?	?	N
Moseley,[47] 1997	?	?	N	N	N	Y	Y	Y
Refshauge et al,[48] 2006	Y	N	N	N	Y	Y	Y	Y
Rose et al,[49] 2010	Y	Y	N	N	Y	Y	Y	Y
Sheehan et al,[50] 2006	Y	Y	N	N	Y	Y	Y	Y
Turton and Britton,[51] 2005	Y	Y	N	N	Y	N	N	N

[a] Y=yes (low risk of bias), N=no (high risk of bias), ?=unclear (either lack of information or uncertainty over the potential for bias).

cates (Fig. 1). After screening titles and abstracts, 102 studies were identified as potentially eligible. After inspecting the full reports, 36 studies were included and 66 were excluded. Twenty-five studies with a total of 812 participants investigated the effects of stretch in people with neurological conditions (Tab. 1).[27–51] An additional 11 studies investigating the effects of stretch in people with non-neurological conditions are reported in the full Cochrane review.[20] The updated search in May and June 2010 identified one additional study not included in the original Cochrane review.[49] The addition of this study explains the very small discrepancies between the results of the Cochrane review and this publication.

The 25 studies of people with neurological conditions investigated the use of stretch in people with stroke, spinal cord injury, Duchenne muscular dystrophy, traumatic brain injury, cerebral palsy, and Charcot-Marie-Tooth disease. Stretch was provided passively (self-administered, therapist-administered, and device-administered) and included positioning, splinting, and serial casting. The stretch dosage was variable, ranging from 30 minutes to 24 hours per day (median=390 minutes, IQR=41–720) for between 7 days and 6 months (median 30=days, IQR=22–60). The total cumulative time that

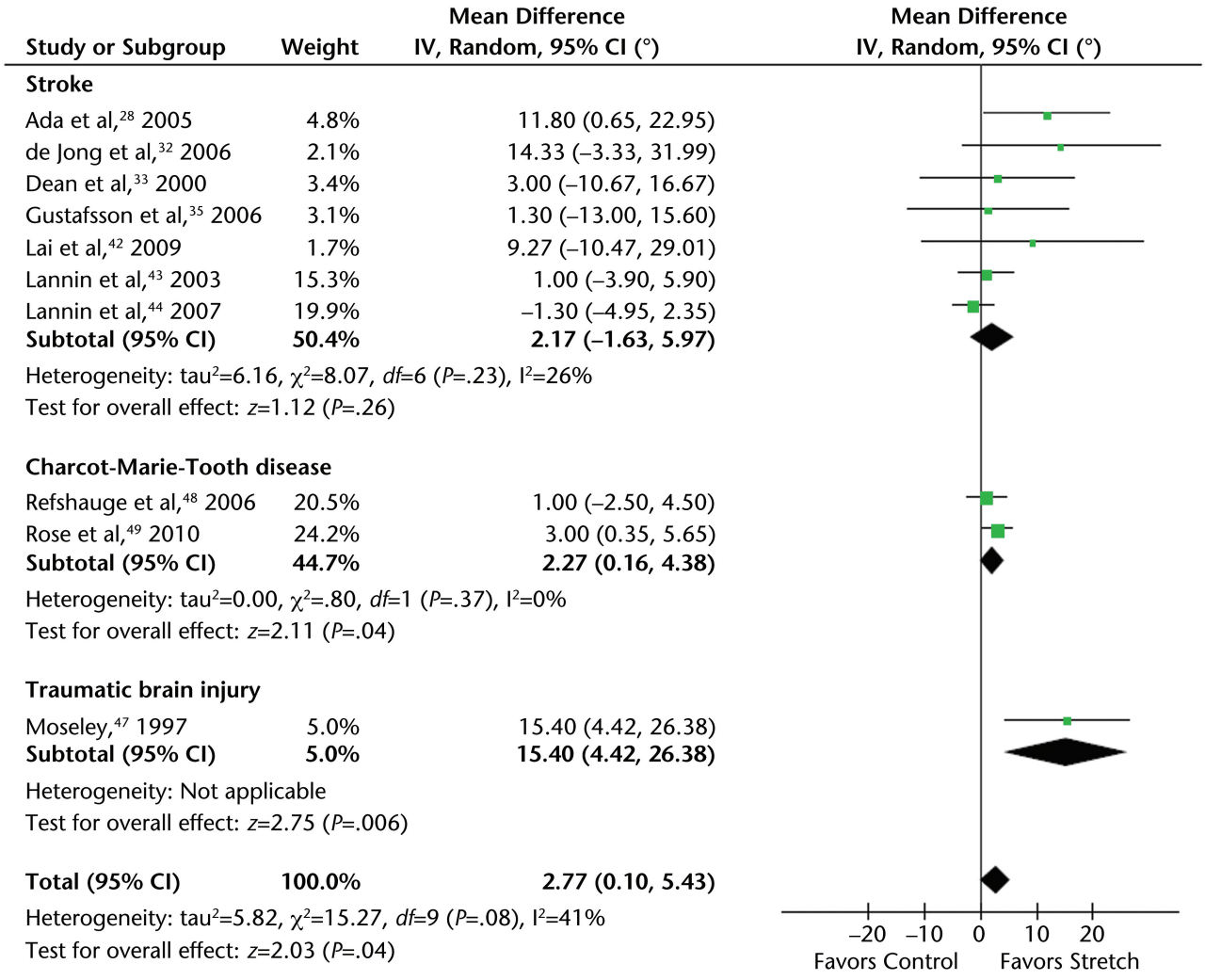


Figure 2.
Forest plot of mean difference with 95% confidence interval (CI) for immediate effects of stretch on joint mobility. IV=inverse variance.

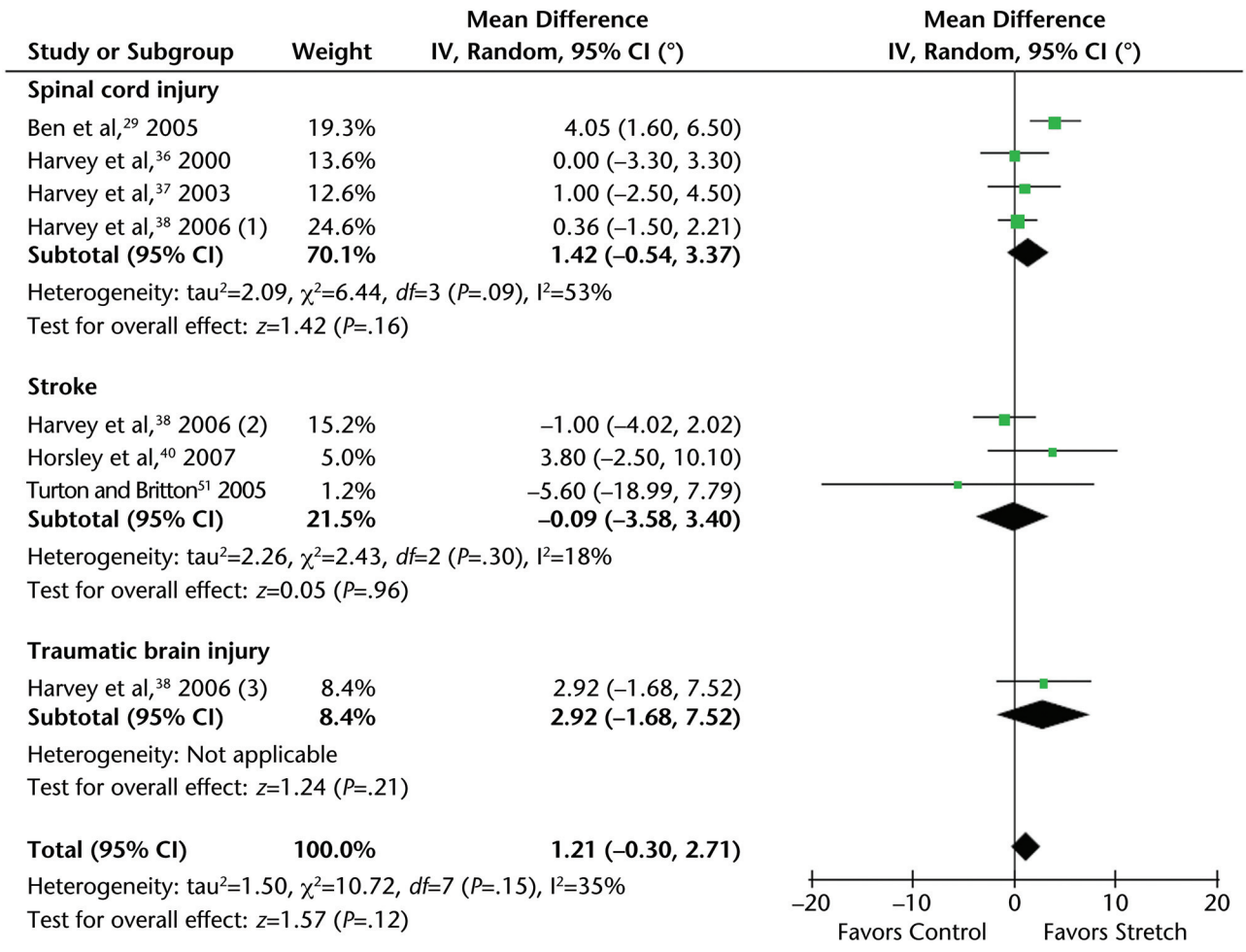
stretch was administered ranged from 8 to 1,512 hours (median=227 hours, IQR=22–672). Joint mobility was reported in all included studies, but quality of life was reported in none. Pain was reported in 9 studies,[28,30–33,35,40,43,44] spasticity was reported in 6 studies,[27,30,32,39,42,44] activity limitation was reported in 13 studies,[28,31,32,34,35,39–41,43–46,49] and participation restriction was reported in 1 study.[38]

Quality of the Evidence

The risk of bias in the 25 studies of people with neurological conditions was variable (Tab. 2). There was risk of bias associated with failure to use adequate methods to generate the randomization sequence (28% of studies), failure to conceal allocation (36% of studies), failure to blind assessors (20% of studies), and inadequate follow-up (36% of studies). Results from all studies were included in the main analyses regardless of quality. When lower-quality studies were excluded in the sensitivity analyses, there was no or little change in the estimates of the effect of stretch.

Effect of Stretch on Joint Mobility

The immediate, short-term, and long-term effects of stretch on joint mobility each were investigated by pooling the data from 10 studies,[28,32,33,35,42–44,47–49] 6 studies,[29,36–38,40,51] and 7 studies,[27,35,36,40,43,44,46] respectively. There is moderate-quality evidence (according to the GRADE criteria) that stretch has a small immediate effect on joint mobility (Fig. 2; mean difference=3°, 95% CI=0° to 5°; I^2=41%; P=.04). There is high-quality evidence (according to the GRADE criteria) that stretch has little or no



(1) Participants with spinal cord injury from 2006 study by Harvey et al[38]
(2) Participants with stroke from 2006 study by Harvey et al[38]
(3) Participants with traumatic brain injury from 2006 study by Harvey et al[38]

Figure 3.
Forest plot of mean difference with 95% confidence interval (CI) for short-term effects of stretch on joint mobility. IV=inverse variance.

short-term or long-term effect on joint mobility (Figs. 3 and 4; mean difference=1°, 95% CI=0° to 3°; I^2=35%; *P*=.12 and mean difference=0°, 95% CI=−2° to 2°; I^2=0%; *P*=.73, respectively).

Effects of Stretch on Pain

The immediate effects of stretch on pain were investigated by pooling data from 4 studies.[31,35,43,44] The standardized mean difference was 0.2 standard deviation (95% CI=−0.1 to 0.6; I^2=14%; *P*=.23). Only one study provided sufficient data to investigate the short-term effects of stretch on pain (ie, pain present 1 week after the cessation of stretch).[40] The mean difference was 0.2 cm on a 10-cm visual analog scale (95% CI=−1.0 to 1.4; *P*=.73). The long-term effects of stretch on pain were investigated by pooling the data from 4 studies.[35,40,43,44] The standardized mean difference was 0.0 standard deviation (95% CI=−0.4 to 0.5; I^2=38%; *P*=.90).

Effects of Stretch on Spasticity

The immediate effects of stretch on spasticity were investigated by pooling the data from 4 studies.[30,32,42,44] The standardized mean difference was 0.1 standard deviation (95% CI=−0.3 to 0.5; I^2=0%; *P*=.69). The long-term effects of stretch on spasticity were investigated by pooling the data from 2 studies.[27,44] The standardized mean difference was −0.3 standard deviation (95% CI=−0.9 to 0.4; I^2=28%; *P*=.41). No study

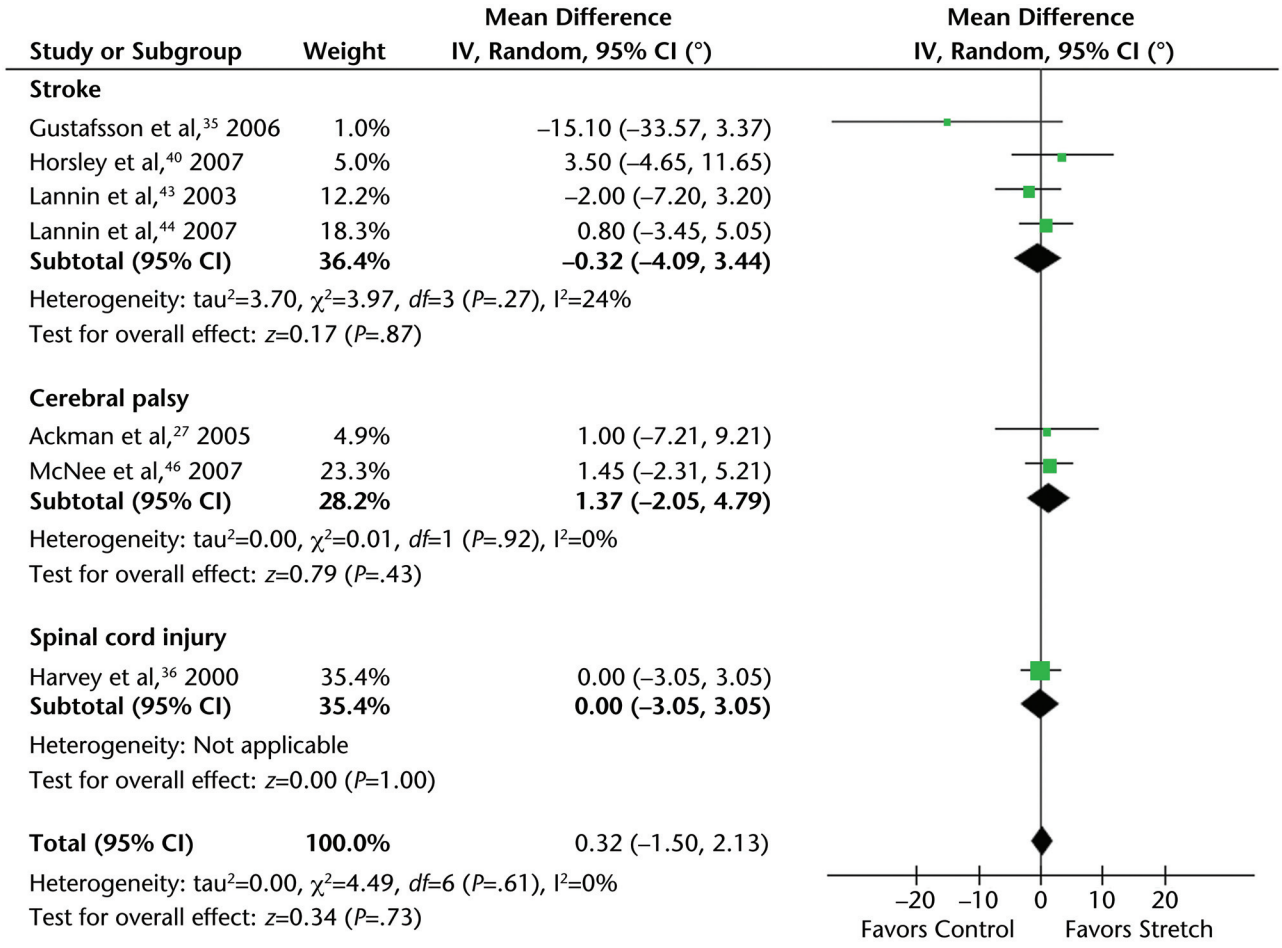


Figure 4.
Forest plot of mean difference with 95% confidence interval (CI) for long-term effects of stretch on joint mobility. IV=inverse variance.

measured the short-term effects of stretch on spasticity.

Effects of Stretch on Activity Limitation and Participation Restriction

The immediate effects of stretch on activity limitation were investigated by pooling the data from 6 studies.[28,35,43–45,49] The standardized mean difference was 0.1 standard deviation (95% CI=−0.2 to 0.5; I^2=42%; *P*=.48). Only 1 study provided sufficient data to investigate the short-term effects of stretch on activity limitation.[40] The mean difference was 2 points on an 18-point scale (95% CI=0 to 4; *P*=.11). The long-term effects of stretch were investigated by pooling the data from 6 studies.[35,40,43–46] The standardized mean difference was 0.2 standard deviation (95% CI=−0.1 to 0.6; I^2=25%; *P*=.19). The effects of stretch on participation could not be determined in any study.

Discussion and Conclusions

The aim of this systematic review was to determine the effects of stretch in people with neurological conditions. The primary outcome measures were joint mobility and quality of life. Secondary outcome measures were pain, spasticity, activity limitation, and participation restriction. The results of this review indicate that stretch does not have clinically important effects on joint mobility in people with or at risk of contractures. There is little or no effect of stretch on pain, spasticity, or activity limitation in people with neurological conditions. Conclusions could not be made about the effects of stretch on quality of life or participation restriction.

Estimates from high-quality studies indicate there were little or no short-term or long-term effects of stretch on joint mobility (mean difference=1° and 0°, respectively, 95% CI=0° to 3° and −2° to 2°, respec-

tively). The precision around both estimates indicates that any possible treatment effect is not greater than 3 degrees. Few authors considered a treatment effect as small as 3 degrees to be clinically important.[33,35,48,49] Estimates from moderate-quality studies indicate that stretch has a small immediate effect on joint mobility (mean difference=3°, 95% CI=0° to 5°, P=.04). Although this effect is statistically significant, the immediate effects of stretch are probably due to viscous deformation and, therefore, are likely to be transient.[5,52] Transient effects of stretch are not intrinsically useful for the treatment and prevention of contractures.

It is possible that the effectiveness of stretch is dependent on the dosage of stretch and how stretch is administered. This possibility was examined in a number of meta-regression analyses not reported in this article but performed as part of the Cochrane systematic review. They indicated that increasing the dosage of stretch did not increase joint mobility and that there was no evidence any particular type of stretch intervention was superior to others. The results of these meta-regressions should be interpreted with caution for 2 reasons. First, they combine the results of neurological and nonneurological populations. Second, they are based on nonrandomized between-study comparisons rather than randomized within-study comparisons.

A common source of bias in systematic reviews is the failure to identify all relevant studies (ie, retrieval bias). Despite our best efforts, potentially eligible studies may have been missed. Nonetheless, the main findings of this review probably are robust because retrieval bias typically increases estimates of effects[53,54] and most estimates of effects in this review are very small. Another source of bias in this systematic review may have been introduced because some of the authors of this systematic review were authors of randomized controlled trials included in the review. To address this issue, review authors did not extract data or assess risk of bias on studies in which they had been involved.

The findings of this systematic review are broadly consistent with the findings of other systematic reviews, once methodological issues are taken into account. Two systematic reviews reported immediate effects of stretch on joint mobility.[55,56] These effects most likely reflect viscous deformation of soft tissues. Not surprisingly, systematic reviews that included nonrandomized studies tended to report more positive results and concluded that stretch was effective in increasing joint mobility.[57–59] In addition, these systematic reviews did not distinguish between immediate and lasting effects of stretch. The most plausible reasons for the discrepancies between our results and those reviews could be viscous deformation of soft tissues and bias from inclusion of nonrandomized studies. A number of systematic reviews examined the long-term effects of stretch, and all concluded either that there is insufficient evidence or that the existing evidence is inconclusive.[9–13,55,60] One recent systematic review used meta-analysis to estimate the effects of stretch for improving joint mobility after stroke.[61] Although that review did not distinguish between the immediate and lasting effects of stretch, the authors concluded that stretch did not improve joint mobility or upper-limb function. These findings are in agreement with the findings of our review.

The studies included in this review compared a stretch intervention with no intervention. However, in all studies, participants in both groups continued to receive usual care with or without other cointerventions (eg, botulinum toxin). Usual care was rarely defined but may have involved the application of regular stretch as part of participants' active and daily routines. For example, it may have involved careful positioning of feet in a wheelchair or bed. It cannot be concluded, therefore, that stretch applied as part of daily routines or as part of other aspects of rehabilitation has no therapeutic effect, nor can it be ruled out that stretch administered over very extended periods of time (ie, years) is ineffective for the treatment or prevention of contracture, as no study examined the effect of stretch administered for more than 6 months. Nonetheless, it is disconcerting that the results of this systematic review indicate no added benefit from stretch as typically applied by therapists. These results challenge long-held beliefs about contracture management and stretch. They indicate that stretch as typically administered by therapists may not be a sufficiently potent stimulus to trigger tissue remodeling. Interestingly, the results from populations without neurological conditions are remarkably similar.[20] These findings indicate a pressing need for reappraisal of effective contracture management and current clinical practice guidelines.

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This is a version of a Cochrane review, which is available in The Cochrane Library, 2010, issue 9 (see www.thecochranelibrary.com

for information). A more-detailed review is published and updated in the Cochrane Database of Systematic Reviews.[19] The results of a Cochrane review can be interpreted differently, depending on people's perspectives and circumstances. Please consider the conclusions presented carefully. They are the opinions of review authors and are not necessarily shared by The Cochrane Collaboration.

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References

1 Fergusson D, Hutton B, Drodge A. The epidemiology of major joint contractures: a systematic review of the literature. *Clin Orthop Relat Res*. 2007;456:22–29.

2 Fox P, Richardson J, McInnes B, et al. Effectiveness of a bed positioning program for treating older adults with knee contractures who are institutionalized. *Phy Ther*. 2000;80:363–372.

3 Lieber RL, Steinman S, Barash IA, Chambers H. Structural and functional changes in spastic skeletal muscle. *Muscle Nerve*. 2004;29:615–627.

4 Harvey L, Herbert R, Crosbie J. Does stretching induce lasting increases in joint ROM: a systematic review. *Physiother Res Int.* 2002;7:1–13.

5 Mollinger LA, Steffen TM. Knee flexion contractures in institutionalized elderly: prevalence, severity, stability, and related variables. *Phys Ther*. 1993;73:437–444.

6 Scott JA, Donovan WH. The prevention of shoulder pain and contracture in the acute tetraplegia patient. *Paraplegia*. 1981;19:313–319.

7 Yarkony GM, Bass LM, Keenan V III, Meyer PR Jr. Contractures complicating spinal cord injury: incidence and comparison between spinal cord centre and general hospital acute care. *Paraplegia*. 1985;23:265–271.

8 *International Classification of Functioning, Disability and Health: ICF.* Geneva, Switzerland: World Health Organization; 2001.

9 Blackmore AM, Boettcher-Hunt E, Jordan M, Chan MD. A systematic review of the effects of casting on equinus in children with cerebral palsy: an evidence report of the AACPDM. *Dev Med Child Neurol.* 2007;49:781–790.

10 Bovend'Eerdt TJ, Newman M, Barker K, et al. The effects of stretching in spasticity: a systematic review. *Arch Phys Med Rehabil*. 2008;89:1395–1406.

11 Lannin NA, Herbert RD. Is hand splinting effective for adults following stroke: a systematic review and methodologic critique of published research. *Clin Rehabil*. 2003;17:807–816.

12 Lannin NA, Novak I, Cusick A. A systematic review of upper extremity casting for children and adults with central nervous system motor disorders. *Clin Rehabil*. 2007;21:963–976.

13 Pin T, Dyke P, Chan M. The effectiveness of passive stretching in children with cerebral palsy. *Dev Med Child Neurol*. 2006;48:855–862.

14 Bohannon RW. Effect of repeated eight-minute muscle loading on the angle of straight-leg raising. *Phys Ther*. 1984;64:491–497.

15 Duong B, Low M, Moseley AM, et al. Time course of stress relaxation and recovery in human ankles. *Clin Biomech (Bristol, Avon)*. 2001;16:601–607.

16 Magnusson SP, Simonsen EB, Aagaard P, et al. Viscoelastic response to repeated static stretching in the human hamstring muscle. *Scand J Med Sci Sports*. 1995;5:342–347.

17 Magnusson SP, Simonsen EB, Aagaard P, Kjaer M. Biomechanical responses to repeated stretches in human hamstring muscle in vivo. *Am J Sports Med*. 1996;24:622–628.

18 Magnusson SP, Simonsen EB, Dyhre-Poulsen P, et al. Viscoelastic stress relaxation during static stretch in human skeletal muscle in the absence of EMG activity. *Scand J Med Sci Sports*. 1996;6:323–328.

19 Tabary JC, Tabary C, Tardieu C, et al. Physiological and structural changes in the cat's soleus muscle due to immobilization at different lengths by plaster casts. *J Physiol*. 1972;224:231–244.

20 Katalinic OM, Harvey LA, Herbert RD, et al. Stretch for the treatment and prevention of contractures. *Cochrane Database Syst Rev*. 2010;9:CD007455.

21 Higgins JP, Altman DG. Assessing risk of bias in included studies. In: Higgins JP, Green S, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. Vol 5.0.2. The Cochrane Collaboration; 2009: Available at: www.cochrane-handbook.org. Updated September 2009. Accessed October 14, 2010.

22 Atkins D, Best D, Briss PA, et al. Grading quality of evidence and strength of recommendations. *BMJ*. 2004;328:1490.

23 Guyatt GH, Oxman AD, Kunz R, et al. What is "quality of evidence" and why is it important to clinicians? *BMJ*. 2008;336:995–998.

24 Guyatt GH, Oxman AD, Vist G, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336:924–926.

25 Schünemann HJ, Jaeschke R, Cook DJ, et al. An official ATS statement: grading the quality of evidence and strength of recommendations in ATS guidelines and recommendations. *Am J Respir Crit Care Med*. 2006;174:605–614.

26 *Review Manager (RevMan)* [computer program]. Copenhagen, Denmark: The Nordic Cochrane Centre, The Cochrane Collaboration; 2008.

27 Ackman JD, Russman BS, Thomas SS, et al. Comparing botulinum toxin A with casting for treatment of dynamic equinus in children with cerebral palsy. *Dev Med Child Neurol*. 2005;47:620–627.

28 Ada L, Goddard E, McCully J, et al. Thirty minutes of positioning reduces the development of shoulder external rotation contracture after stroke: a randomized controlled trial. *Arch Phys Med Rehabil.* 2005;86:230–234.

29 Ben M, Harvey L, Denis S, et al. Does 12 weeks of regular standing prevent loss of ankle mobility and bone mineral density in people with recent spinal cord injuries? *Aust J Physiother*. 2005;51:251–256.

30 Burge E, Kupper D, Finckh A, et al. Neutral functional realignment orthosis prevents hand pain in patients with subacute stroke: a randomized trial. *Arch Phys Med Rehabil*. 2008;89:1857–1862.

31 Crowe J, MacKay-Lyons M, Morris H. A multi-centre, randomized controlled trial of the effectiveness of positioning on quadriplegic shoulder pain. *Physiother Can*. 2000;52:266–273.

32 de Jong LD, Nieuwboer A, Aufdemkampe G. Contracture preventive positioning of the hemiplegic arm in subacute stroke patients: a pilot randomized controlled trial. *Clin Rehabil*. 2006;20:656–667. Erratum in *Clin Rehabil*. 2010;24:767.

33 Dean CM, Mackey FH, Katrak P. Examination of shoulder positioning after stroke: a randomised controlled pilot trial. *Aust J Physiother*. 2000;46:35–40.

34 DiPasquale-Lehnerz P. Orthotic intervention for development of hand function with C-6 quadriplegia. *Am J Occup Ther*. 1994;48:138–144.

35 Gustafsson L, McKenna K. A programme of static positional stretches does not reduce hemiplegic shoulder pain or maintain shoulder range of motion: a randomized controlled trial. *Clin Rehabil*. 2006;20:277–286.

36 Harvey LA, Batty J, Crosbie J, et al. A randomized trial assessing the effects of 4 weeks of daily stretching on ankle mobility in patients with spinal cord injuries. *Arch Phys Med Rehabil*. 2000;81:1340–1347.

37 Harvey LA, Byak AJ, Ostrovskaya M, et al. Randomised trial of the effects of four weeks of daily stretch on extensibility of hamstring muscles in people with spinal cord injuries. *Aust J Physiother*. 2003;49:176–181.

38 Harvey L, de Jong I, Goehl G, Mardwedel S. Twelve weeks of nightly stretch does not reduce thumb web-space contractures in people with a neurological condition: a randomised controlled trial. *Aust J Physiother*. 2006;52:251–258.

39 Hill J. The effects of casting on upper extremity motor disorders after brain injury. *Am J Occup Ther*. 1994;48:219–224.

40 Horsley SA, Herbert RD, Ada L. Four weeks of daily stretch has little or no effect on wrist contracture after stroke: a randomised controlled trial [erratum in *Aust J Physiother*. 2008;54:38]. *Aust J Physiother*. 2007;53:239–245.

41 Hyde SA, FlLytrup I, Glent S, et al. A randomized comparative study of two methods for controlling Tendo Achilles contracture in Duchenne muscular dystrophy. *Neuromuscul Disord*. 2000;10:257–263.

42 Lai JM, Francisco GE, Willis FB. Dynamic splinting after treatment with botulinum toxin type-A: a randomized controlled pilot study. *Adv Ther*. 2009;26:241–248.

43 Lannin NA, Horsley SA, Herbert R, et al. Splinting the hand in the functional position after brain impairment: a randomized controlled trial. *Arch Phys Med Rehabil*. 2003;84:297–302.

44 Lannin NA, Cusick A, McCluskey A, Herbert RD. Effects of splinting on wrist contracture after stroke: a randomized controlled trial. *Stroke*. 2007;38:111–116.

45 Law M, Cadman D, Rosenbaum P, et al. Neurodevelopmental therapy and upper-extremity inhibitive casting for children with cerebral palsy. *Dev Med Child Neurol*. 1991;33:379–387.

46 McNee AE, Will E, Lin JP, et al. The effect of serial casting on gait in children with cerebral palsy: preliminary results from a crossover trial. *Gait Posture*. 2007;25:463–468.

47 Moseley AM. The effect of casting combined with stretching on passive ankle dorsiflexion in adults with traumatic head injuries. *Phys Ther*. 1997;77:240–247.

48 Refshauge KM, Raymond J, Nicholson G, van den Dolder PA. Night splinting does not increase ankle range of motion in people with Charcot-Marie-Tooth disease: a randomised cross-over trial. *Aust J Physiother*. 2006;52:193–199.

49 Rose K, Raymond J, Refshauge K, et al. Serial night casting increases ankle dorsiflexion range in children and young adults with Charcot-Marie-Tooth disease: a randomised trial. *J Physiother*. 2010;56:113–119.

50 Sheehan JL, Winzeler-Mercay U, Mudie MH. A randomized controlled pilot study to obtain the best estimate of the size of the effect of a thermoplastic resting splint on spasticity in the stroke-affected wrist and fingers. *Clin Rehabil*. 2006;20:1032–1037.

51 Turton AJ, Britton E. A pilot randomized controlled trial of a daily muscle stretch regime to prevent contractures in the arm after stroke [erratum in *Clin Rehabil*. 2006;20:91]. *Clin Rehabil*. 2005;19:600–612.

52 Weppler CH, Magnusson SP. Increasing muscle extensibility: a matter of increasing length or modifying sensation? *Phys Ther*. 2010;90:438–449.

53 Dickersin K, Min YI. NIH clinical trials and publication bias. *Online J Curr Clin Trials*. 1993;Doc No 50.

54 Egger M, Smith GD. Bias in location and selection of studies. *BMJ*. 1998;316(7124):61–66.

55 Hellweg S, Johannes S. Physiotherapy after traumatic brain injury: a systematic review of the literature. *Brain Inj*. 2008;22:365–373.

56 Autti-Ramo I, Suoranta J, Anttila H, et al. Effectiveness of upper and lower limb casting and orthoses in children with cerebral palsy: an overview of review articles. *Am J Phys Med Rehabil*. 2006;85:89–103.

57 Michlovitz SL, Harris BA, Watkins MP. Therapy interventions for improving joint range of motion: a systematic review. *J Hand Ther*. 2004;17:118–131.

58 Mortenson PA, Eng JJ. The use of casts in the management of joint mobility and hypertonia following brain injury in adults: a systematic review. *Phys Ther*. 2003;83:648–658.

59 Teplicky R, Law M, Russell D. The effectiveness of casts, orthoses, and splints for children with neurological disorders. *Infants Young Child*. 2002;15:42–50.

60 Van Peppen RP, Kwakkel G, Wood-Dauphinee S, et al. The impact of physical therapy on functional outcomes after stroke: what's the evidence? *Clin Rehabil*. 2004;18:833–862.

61 Borisova Y, Bohannon RW. Positioning to prevent or reduce shoulder range of motion impairments after stroke: a meta-analysis. *Clin Rehabil*. 2009;23:681–686.