How effective is stretching in maintaining range of movement for children with cerebral palsy?
A Critical Review

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Abstract

Background: Cerebral Palsy (CP) is the most common childhood disorder affecting four percent of children born in the UK. It is common for children with CP to have reduced range of movement (ROM) due to spasticity and contractures. Stretching is commonly used in physiotherapy programmes to manage this.

Aim: This critical review aims to evaluate the evidence base behind the use of stretching for children with CP.

Methods: A systematic literature search of AMED, CINAHL, MEDLINE and Cochrane Library Trials was conducted. Returned searches were assessed against strict criteria according to a predefined PICOS (Population, Intervention, Comparison, Outcome, Study). These studies were then critically appraised to assess the validity, reliability and clinical relevance.

Findings: There is evidence supporting the use of stretching in children with CP. However there is also some evidence to suggest very little or no positive change. All of the included studies have methodological limitations, which questions the validity of the results.

Conclusions/Recommendations: The research suggests some positive outcomes for the use of stretching in CP, studies that did not find positive outcomes found no adverse effects; however further research in the area is required to validate the effectiveness of stretching to maintain ROM in children with CP.

Key Words: cerebral palsy, stretching, children, spasticity, contractures.

Introduction

This critical review will examine the use of stretching on range of movement (ROM) in children with cerebral palsy (CP). CP is a common child development disorder (Eunson, 2012). It is estimated that four percent of children born in the UK have CP (CerebralPalsy.org, 2015). This equates to approximately 28,000 children a year, at current birth rates.

A guideline on the diagnosis and management of CP is currently being developed, (anticipated publication, 2017, National Institute for Health and Care Excellence,

2015). However this will not include spasticity management therefore the 2012 National Institute for Health and Care Excellence (NICE) guideline on spasticity in children and young people with non-progressive brain disorders can be applied. This guideline gives a range of interventions used to manage spasticity, which includes low-load active or passive stretching as a specific strategy for postural management (Guideline 1.2.9).

Cans et al. (2007) defines CP as 'a group of permanent, but not unchanging, disorders of movement and/or posture and of motor-function, which are due to non-progressive interference, lesion, or abnormality of the developing brain.' CP is classified in three main ways; these are outlined in table one. The International Classification of Functioning, Disability and Health (ICF) can also be applied to CP children. This framework focuses on the impact of disability and health and allows a comparison of disability using a biopsychosocial approach (World Health Organization, 2014).

Table one here

Spastic CP is the most common, presenting in 75% of cases. Children with CP frequently have reduced ROM due to contractures (CerebralPalsy.org, 2015). The exact cause of contractures is debatable but there is agreement both neural and non-neural factors are involved (Lieber et al., 2004). Neural elements relate to spasticity resulting from damage to the upper motor neuron, which decreases cortical input to the descending spinal tracts. This can cause a reduction in the number of voluntary active units within the muscle and hyperactive reflex arcs, which can cause weakness, decreased motor control and excessive muscle contraction. This produces an increase in spindle sensitivity resulting in muscle shortening which directly affects the ROM (Shamsoddini et al, 2014). Changes within the soft tissues lead to shortening of structures surrounding the joint and are responsible for non-neural elements of contractures (Mathewson and Lieber, 2015).

Secondary problems of contractures can include: muscle pain, spasms, difficulties with activities of daily living, poor seating position, reduced mobility, bone deformities, joint instability, subluxation and early development osteoarthritic

changes (Papavasiliou, 2009; Shamsoddini et al., 2014). It is therefore important to evaluate the effects of physiotherapy stretching programmes (diagram one) for children with CP. Physiotherapy aims to prevent these secondary changes, maintain current abilities and increase ROM, which may result in improved functional outcomes when classified against the ICF framework (NICE, 2012).

Diagram one here

Literature Review

There is little research investigating stretching for children with CP, despite its high prevalence compared to other neurological disorders (Tilton, 2006). The themes identified within the critical review aimed to be comprehensive but are by no means exhaustive.

Nakamura et al. (2014) found active muscle stretching effective in increasing ROM in adult male participants with no neurological conditions. It has been suggested passive stretching reduces muscle tissue stiffness, most likely by signalling connective tissue remodelling and may also increase the number of sarcomeres (Riley and Van Dyke, 2012). These findings cannot be directly applied to the paediatric CP populations as they have differences in their muscle structure. These differences include; stiffness within the muscle fiber bundle resulting in a reduced muscle volume and a stiffening of the extracellular matrix due to increased collagen content and sarcomere length (Barber et al., 2011a; Smith et al., 2011). There is also a suggestion that muscle fascicles are shorter in CP children (Mohagheghi et al, 2008) however there is some debate surrounding this (Barber et al., 2011b; Mathewson and Lieber, 2015).

Bovend'Eerdt et al. (2008) and a Cochrane Systematic Review by Katalinic et al. (2010) did not find conclusive evidence to support stretching to improve spasticity in adults. These results cannot be directly applied as children may respond differently to treatment, require different treatment intensities and their development may impact on the results (Wallen and Stewart, 2013).

A 2014 parliamentary inquiry highlighted the need for early identification, assessment and intervention for children with CP (Action CP, 2015). Yang et al. (2013) estimated the critical period for early intervention is before the age of two. In these early years, neuroplasticity of the brain is maximal and more receptive to interventions. This provides an opportunity for therapy to mitigate symptoms, enable children to reach their full potential in improving function and therefore potentially improve outcomes when classified by the ICF (Barber, 2008; Action CP, 2015).

Franki et al. (2012) found small improvements in ROM when stretching is combined with electrical stimulation, heat application or strengthening programmes. This is also supported by randomized control trials (RCT's) by Wu et al. (2011) and Elshafey et al. (2014). Although these studies found a beneficial effect of stretching within combined treatment programmes, it is impossible to identify the effectiveness of stretching alone.

A study by Tardieu et al. (1988) found that a muscle must be stretched for at least six hours a day to prevent contracture development. Low-load passive stretching is commonly used on children with CP using splints, casts, orthotics and tilt tables (Papavasiliou, 2009). Tardieu et al. (1988) found the use of orthotics to be an effective method to provide the necessary long-term stretch. Autti-Ra et al. (2006) also found short-term effects for the use of casting in the lower limb but was inconclusive for the upper limb. In clinical practice the use of splints, casts and orthotics in order to gain a prolonged stretch has been found to cause adherence issues.

A review by Pin et al. (2006) found some evidence of passive stretching increasing range of movement and reducing spasticity in children with CP. However not all participants had a diagnosis of CP. A systematic review by Wiart et al. (2008) reviewed evidence dating back to 1984 and found a lack of understanding of muscle contractures and research underpinning the use of stretching with children with CP. However both of these reviews include studies using combined interventions.

It is clear from the literature that there is uncertainty regarding the mechanism of muscle stretching; however it is thought that stretching can promote muscle growth

(Shamsoddini, 2014) and lead to changes in the muscles viscoelastic, structural and excitability properties. The structures under tension during a stretch can include: muscle, tendon, connective tissue, vascular tissue, dermal tissue and neural tissue (Bovend'Eerdt et al., 2008).

The aim of this review is to solely focus on the effect of stretching as a single intervention in children with CP on ROM.

Methodology

A systematic approach to literature searching is important to ensure a thorough search that delivers credible findings (Booth et al., 2012). The PICOS method was utilised to create a comprehensive search strategy returning specific results (Bettany-Saltikov, 2012). The terms used were identified through background research. Table two outlines the PICOS used.

Table two here

An electronic search was conducted of AMED, CINAHL, MEDLINE and Cochrane Library Trials in January 2015. Where possible, all terms were searched as medical subheadings. If no return, it was searched as a keyword. Table three outlines the database searches.

Table three here

The outcome 'range of movement' was omitted from the search, despite being in the PICOS, as initial searches returned irrelevant articles. Higgins and Green (2011) suggest that equal emphasis on each component of the PICOS is not necessary and outcomes are not usually considered part of the search.

Booth et al. (2012) suggests electronic searching can still miss important published studies. Hand searching by examining the bibliographies or reference lists of relevant reviews can prevent this. Therefore hand searching of five relevant reviews was conducted (Pin et al., 2006, Gorter et al., 2007, Wiart et al., 2008, Franki et al.,

2012, Wallen and Stewart, 2013). In searching for the full article of Kaur (2010), another relevant article was found by the same author.

The full search (inclusive of hand searching) returned 152 articles. After removing duplicates, an assessment of title and abstract against inclusion and exclusion criteria was completed. A PRISMA form (Moher et al., 2009) outlining the overall search process is shown in diagram two.

Diagram two here

Full text assessment of seven remaining articles against the criteria was completed (see diagram two). An excluded article, Kaur (2009), appeared to be a duplicate piece of research already included in the search. A critical analysis and comparison of these studies in order to find the most applicable is shown in appendix one.

The final four studies were critically appraised using Bellini and Rumrill (1999) appraisal tool and then graded using the Scottish Intercollegiate Guidelines Network (SIGN) grading tool (SIGN, 2014). Table four provides an outline of each article, their grade, alongside their strengths and weaknesses. All four articles have been presented in one table to enable easy comparison.

Table four here

Findings

Table four indicates that one case series and three RCT's were included in this critical review, all of which are quantitative studies using static dorsiflexion stretching interventions. Although there are some differences in the outcomes measured, all contribute to ROM. Other relevant studies were found during the initial search but for the purpose of this review the evidence was limited to the last 15 years. The included articles will be discussed further using a thematic narrative analysis.

Spasticity

Three of the studies directly measure spasticity. Tremblay et al. (1990) found spasticity was reduced, Richards (1991) was inconclusive and Kaur (2010) found no change. Tremblay et al. (1990) found statistically significant reductions ($p<0.05$) in neuromuscular responses and resistance to a passive stretch. There were some difficulties with participant assignment to treatment groups leading to an imbalance of the level of disability along with the exclusion of two participants due to technical problems. However, pre-intervention tests showed no statistically significant difference between groups.

Richards et al. (1991) used ambulant patients from Tremblay et al (1990) and found a statistically significant ($p<0.01$) decrease in neuromuscular responses of the tibialis anterior muscle during a small section of the gait cycle (0-16%). However this was the only significant finding. The randomisation of participants was not completed in stratified blocks for disability, leading to the uneven distribution of participants between the experimental and control groups. The effect of this was statistically evaluated and found to have no significant impact on the findings.

Kaur (2010) used the Modified Ashworth Scale (MAS) and found that stretching did not lead to statistically significant changes ($p>0.05$) in spasticity. There is great concern as to the overall quality of the study; within the article there are inconsistencies in the methodological processes completed, thus questioning the validity and reliability of the research and its findings.

Soft Tissue Length

Theis et al. (2013) found stretching increased both ROM and the length of soft tissues. Ankle dorsiflexion was increased by 10°, which was accounted for by elongations of 0.8 cm of muscle, 1.0 cm of tendon and 0.6cm of fascicle. These all had statistical significance ($p<0.001$). Maximum muscle length was progressively increased during the five stretches. Medial gastrocnemius muscle fascicle length was only quantified in six of the eight participants. There is no explanation offered for this, which questions the true validity of the findings. This study uses different stretching techniques and timing protocols to the other studies therefore reducing the clinical homogeneity.

Different Stretching Technique

Theis et al. (2013) was the only study to explore the impact of different stretching techniques. The study compared a stretch given by a physiotherapist and a self-stretch. They found the difference in improvements post stretching were not statistically significant ($p>0.05$). Therefore the improvements seen from stretching were independent of stretch technique. Within the study it is discussed that the self-stretch was completed under supervision of a physiotherapist so does not rule out the possibility it would be less effective without supervision.

Duration

Only Tremblay et al. (1990) and Kaur (2010) studied the duration of the outcomes. Kaur (2010) retested MAS 45 minutes after completion of the intervention and found there were still no changes to spasticity. Tremblay et al. (1990) retested outcomes at 25 and 35 minutes. The positive effects were still present 35 minutes after treatment ($p<0.05$). However, out of a sample of 22 children, only 18 were re-tested at 25 minutes and 14 at 35 minutes. No explanations are provided for this, which could lead to attrition bias affecting the findings.

Additional Findings

Tremblay et al. (1990) and Richards et al. (1991) also recorded other outcomes that do not directly relate to ROM. Tremblay et al. (1990) found the ability to voluntarily contract the plantarflexors of the ankle was significantly ($p<0.05$) improved after stretching but there was no change to the dorsiflexors. This is also supported by

Richards et al. (1991) who did not find statistically significant ($p>0.05$) changes in any gait parameters.

Discussion

This review highlights that there is contradicting evidence. Tremblay et al., (1990) and Theis et al., (2013) found stretching can be beneficial in increasing ROM by reducing spasticity and lengthening soft tissues. The effect on soft tissues is independent of the stretch technique used. However there is contradictory evidence that suggests stretching does not have an effect on spasticity (Kaur, 2010). Richards et al (1991) was inconclusive.

The study presenting the most statistically significant findings (Theis et al., 2013) has the lowest ranking in the hierarchy of evidence (Rosner, 2012) (table four). The other studies are RCT's, although they are the 'gold standard' of research (Tomlinson et al., 2015) they have significant methodological flaws. All the studies lack blinding, allocation concealment and control over other potentially confounding factors, which jeopardise the validity and reliability of the findings (table four).

Sample

The age range included in the studies is from three to fourteen. This could affect the impact of the intervention, as the children would be at different stages of development. As discussed above, Yang et al. (2013) suggests the optimal time for intervention is before the age of two. The children included in the studies are all above this optimal age of neuroplasticity. Furthermore the eldest child is seven times this optimal age; thus suggesting there are significant differences in neuroplasticity. There is also variation in the disability level included within the studies. If the studies had utilised the ICF, it may have allowed for trustworthy comparison across different disability levels. Interestingly, the most significant positive findings were found where there were the least variation in disability (Thesis et al. 2013).

All studies have small sample sizes, eight to 22, and two of the studies (Tremblay et al., 1990; Richards et al., 1991) use the same participants. This reduces the findings of this review and the generalizability of the two studies. Power calculations have not

been used in any of the studies to establish the sample size required for the findings to be statistically significant (Suresh and Chandrashekara, 2012).

Intervention

Different methods of stretching between the studies include: self-applied stretch, stretch applied by a physiotherapist and a tilt table. The differing methods place varying loads on the body, which could alter the bodies' automatic response. Application of the stretch may also vary between techniques, therefore impacting on the results. All studies use static stretching techniques; diagram one shows there are other types of stretching, each may produce different results. However, the 2012 NICE guidance suggests the use of low-load passive or active stretching but does not highlight one as preferable to the other. Additionally, Theis et al. (2013) found the significant changes were independent of the technique used.

The length of intervention varies from five repetitions of 20 seconds to 30 minutes. However, Tardieu et al. (1988) found that the soleus muscle must be stretched for a minimum of six hours a day to prevent contractures. The length of intervention in the studies may not have been long enough to fully assess the results. Inconsistencies in the Kaur (2010) article gave uncertainty concerning treatment durations. Differences in duration and number of treatment sessions could impact the results found. Additionally if the research was completed over a longer time period, the intervention may be more effective and differing results found.

Outcomes

Each study utilises different methods of recording outcomes. The variation in precision and reliability could impact on the validity of the findings.

Kaur (2010) uses the MAS, but there is no discussion of how this was recorded and again questions the reliability of the study. MAS and ROM are commonly used in practice whereas methods to record neuromuscular responses and soft tissue length require specialist equipment. It is thought that the Tardieu Scale is more effective at measuring spasticity than the MAS and has an excellent intrarater and interrater reliability (Gracies et al. 2010). However it is more complex to complete, which suggests the MAS and ROM measures would be more effective in clinical practice.

Richards et al. (1991) assessed clinical outcomes during gait differing to the other studies, which recorded outcomes when static. It is suggested the response of semiautomatic gait muscle activations is not the same as reflex and voluntary muscle activations. Therefore the study findings may be inconsistent with the others despite it satisfying inclusion criteria for this review; this is again indicative of the lack of research in this area.

There is a lack of understanding demonstrated in general research of the theories behind contractures and stretching (Wiart et al., 2008). Therefore it is difficult to determine if the variation is from the research techniques used, body response, or a combination. Stretching is commonly used in practice to maintain ROM in children with CP (Papavasiliou, 2009). Although this study found inconclusive evidence regarding stretching, no adverse effects were recorded. Therefore the continued use in practice is valid, although it varies across the full age range and disabilities.

Conclusion

CP affects four percent of children born in the UK. Stretching is a commonly used intervention to maintain ROM as part of a child's physiotherapy programme. There is a lack of specific evidence supporting or refuting this. A critical review has been conducted by a pair of reviewers, to determine the quality of the evidence available. The search returned 95 studies; using strict criteria this was reduced to four (see diagram two). These articles were critically appraised to establish the quality of the evidence and the following conclusions have been drawn:

There is some positive research supporting the use of stretching to improve ROM in children with CP. However some of the evidence also found stretching to have very minor or no effect on ROM. All the studies have limitations, which reduce the validity and reliability of the findings (table four). There is no evidence to suggest that stretching has a detrimental effect on children. So in practice the use of stretching is deemed safe to continue, however further research is required to validate the effectiveness of its use, determine the type of stretch, duration and how it should be applied.

Recommendations for Practice and Further Research

- Stretching should still be used as there is some evidence for potential gain in lower level disability groups and no adverse effects have been observed. However more research is required to determine clinical effectiveness.
- Further research is required to be able to fully assess the efficacy of using stretching to maintain ROM in children with CP.
- From the review conducted, it is clear that the target population should include age groups starting as soon as possible after birth, before two, and at defined intervals throughout childhood.
- Power calculations should be completed to identify the sample size required to achieve statistically significant results relevant to the target population.
- Research should be specific to each disability group. The review indicates a better outcome in the lower levels of disability therefore this group would be logical to commence with.
- The intervention should be standardised to ensure consistent application.
- Research should be completed over a longer period with follow up assessments to determine the longevity of the intervention.
- Outcome measures used should be applicable to practice but also verifiable with more precise techniques.
- NICE guidelines for CP could consider the development of CP specific guidance on managing contractures and spasticity and within it evaluate the role of stretching.

Conflicts of interest: none declared.

Key Points:

- It is common for children with CP to have a reduced range of movement (ROM) due to spasticity and contractures.
- Stretching is commonly used to maintain range of movement as part of a physiotherapy programme for children with CP.
- There is some evidence for potential gain using stretching to maintain ROM in children with lower level disability CP.
- No adverse effects have been observed in the studies.

- Further research is required to fully assess the efficacy of using stretching to maintain ROM in children with CP.

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Appendix One – Comparison of Kaur Articles

Article	Kaur (2009)	Kaur (2010)
Similarities	• Inclusion and exclusion criteria. • Same method of stretch. • Same data analysis: paired t-tests and the use of SPSS software. • Almost identical introductions. Kaur (2010) has slightly more information. • Collection of participant demographic profile and medical history through interview and medical records. • Same institutional review board approval gained. • No significant difference in results in tone. • Almost identical limitations of the study highlighted.	
Differences	• Convenience sampling method used to recruit and group participants. • Inconsistency in number of participants - 30 in beginning and 20 at the end. • Intervention given over a period of two weeks with testing on first and last day. • Measured muscle spasticity with MAS and ROM. • Treatment for 30 minutes, per session, per day, 5 days a week for 2 weeks. • Significant change in ROM found.	• Recruited participants using a random sampling method. • 20 participants randomly assigned to groups. • All interventions and tests completed on one day. • Measured muscle spasticity using the MAS. • Treatment time not clearly specified. Abstract states 45 minutes, per session, per day, 5 days a week for 2 weeks, methodology states 30 minutes on one day and the discussion 45 minutes on one occasion.
Strengths	• Theoretical rationale behind study. • Findings supported with other research. • Weaknesses of the study highlighted. • Ethical approval gained. • Informed written consent of all participants' parents or carers gained.	• RCT study design, which is appropriate for the research question. • Clear research aim. • Specific population studied through inclusion/exclusion criteria. • Theoretical rationale underpinning the need for the study.

	• Outcome measure used relevance to clinical practice. • Specific population studied through inclusion/exclusion criteria. • Clear research aim. Use of statistical tests to compare groups and SPSS software for data analysis. • No participant drop out. • Free from selective reporting. • Framework of study supported by research. • Analysis of results with participants in intervention groups. • Specific eligibility criteria. • Controlled intervention.	• Use of statistical tests to compare groups and SPSS software for data analysis. • Participants recruited using a random sampling method. • Participants assigned to groups using a random sampling method. • Outcome measure used relevance to clinical practice. • Informed written consent gained for all participants. • Discussion of the limitations of the study. • No participant drop out. • Study framework supported by evidence. • Findings supported with current research for the study. • Ethical approval gained. • Experimental and control groups similar at the start of the study. • Free of selective reporting. • Analysis of results with participants in intervention groups. • Specific eligibility criteria. • Controlled Intervention
Weaknesses	• No randomisation. • No discussion of blinding. • Inconsistency in participant numbers. • No discussion of allocation concealment. • Small sample size. • Participants recruited using convenience sampling. • Small geographic area of participant recruitment. • Lack of discussion surrounding techniques	• Small sample size. • No description of the study setting. • Short time frame of study. • No discussion of allocation concealment. • No discussion of the geographic area of the recruitment process. • No discussion of the assessors and their experience, blinding and involvement in the research. • Lack of sensitivity of the MAS. • Limited explanation of control intervention.

	used. • Small number of dated references used. • Short time scale of the study. • No discussion of the different demographics of the groups. • No confidence intervals. • Completed in three different clinics. • Small number of outcomes measured. Both of which are susceptible to differences between assessors. • Clinical importance not discussed. • No discussion of the assessors and their experience, blinding and involvement in the research. • Did not monitor any other potentially confounding factors. • No pilot study.	• No text surrounding the results. • No control over other potentially confounding factors. • Little discussion over the validity, precision and reliability of the processes used. • No discussion of the results impact on future research or practice. • Only one outcome measure studied. • No confidence intervals. • A small range of references used. • No pilot study. • The abstract, methodology and discussion sections all have different treatment protocols outlined.

Tables From Document

Table one: classification of cerebral palsy.	
Classification	**Further Details**
Area of body that is affected	• Hemiplegia. • Diplegia. • Tetraplegia/quadriplegia. (Shamsoddini et al., 2014)
Disorder type	• Spastic. • Athetoid. • Ataxic. • Hypotonic. (Eunson, 2012)
Gross Motor Function Classification System (GMFCS)	• Scores a child's mobility on a scale of one to five. (Mathewson and Lieber, 2015).

Table two: PICOS used for search.	
Population	Children (0-18) Cerebral Palsy
Intervention	Stretching Muscle stretching Muscle stretching exercises Prolonged muscle stretch Passive muscle stretch Active muscle stretch
Comparison	None
Outcome	Range of Movement
Study	World wide English Language Able to access full text

Table three: Database searches.					
Search ID	Search Term	CINAHL	AMED	MEDLINE	Cochrane Library Trials
S1	Cerebral Palsy	7,643	2,406	15,885	1,809
S2	Stretching	3,359	995	20,098	1,825
S3	Muscle Stretching	99	303	1,196	1,074
S4	Muscle Stretching Exercises	10	162	975	718
S5	Prolonged	3	3	3	63

	Muscle Stretch				
S6	Passive Muscle Stretch	12	27	61	227
S7	Active Muscle Stretch	0	15	7	244
S8	S2 OR S3 OR S4 OR S5 OR S6 OR S7	3,392	1,025	20,155	1,995
S9	S1 AND S8	32	26	74	76
Limits	All child (0-18), English language.	25	18	59	30

Table four: Outline of each study and its strengths and weaknesses. (Using Bellini and Rumrill, 1999)				
Article	Theis et al., 2013 A Case Series.	Kaur, 2010 **A Randomized Control Trial.**	Richards et al., 1991 **A Randomised Control Trial.**	Tremblay et al., 1990 **A Randomised Control Trial.**
Grade of Evidence (SIGN, 2014)	3	1-	1+	1+
Aim	• Is the alteration in ankle ROM in response to acute stretching accompanied by increases in muscle length? • Are any effects dependent upon the stretch technique?	• Evaluate prolonged muscle stretching on ankle plantar-flexor spasticity.	• Study the effect of a single session of passive plantarflexor stretching on activations of plantarflexors and the antagonist dorsiflexors during gait.	• Investigate the effect of a single session of prolonged stretching on reflex and voluntary muscle contractions.
Sample	• Recruited via NHS paediatric physiotherapy services. • Intervention group (8 participants, mean age 10.2, GMFCS: 5 at level 2 and 3 at level 1). • Inclusion Criteria - Diagnosis of spastic diaplegic CP. • Exclusion criteria: - Orthopaedic surgery.	• Random sampling method used for recruitment and group assignment. • Experimental group (10 participants, mean age 5.8, 4 quadriplegic, 6 diplegic). • Control group (10 participants, mean age 6.1, 6 quadriplegic, 4 diplegic.)	• Recruited from a rehabilitation centre. • Randomly assigned into two groups from a parallel study (Tremblay et al., 1990). • Experimental group (8 participants, mean age 7, 6 diplegic, 2 hemiplegic). • Control group (11 participants, mean age 7, 6 diplegic, 5 hemiplegic).	• Recruited from a rehabilitation centre. • Randomly assigned to groups but without stratification for the plegia. • Experimental group (12 participants, mean age 7, 8 diiplegics, 2 tetraplegics, 2 hemiplegic). • Control group (10 participants, mean age 5.9, 5 diplegics, 5

	- Botulinum toxin injection.	• Inclusion criteria: - Spasticity grade 1-3 on MAS. • Exclusion criteria: - Spastic hemiplegia or monoplegia. - Limb length discrepancy. - Foot bony deformities oedema. - Surgery to tibialis anterior. - Medical disorders.	• Inclusion criteria: - Clinical spasticity in plantarflexors. - Ability to walk 10m unassisted. - Mentally capable to complete the tests. • Exclusion criteria: - Surgery to the legs.	hemiplegics). • Inclusion Criteria: - Medical diagnosis of spastic cerebral palsy. - No surgical procedures to the triceps surae. - No fixed deformities of the ankle joint. - Ability to cope with requirements.
Methodology	• Intervention: - Passive or self-stretch. - Completed 5 times, held at maximum range for 20 seconds, 60 second rest in-between. - Minimum 60 minutes rest between stretch techniques on one leg. - Order of leg and technique was randomised.	• Interventions: - Experimental group: positioned on a tilt table with ankles in maximal dorsiflexion. - Control group: conventional physiotherapy consisting of passive exercises - no further explanation. - Treatment time not clearly specified – discrepancies within the text.	• Interventions: - Experimental group: stood, with a modified tilt table for 30 minutes, keeping the ankle in maximal dorsiflexion. Whilst engaged in educational activities. - Control group: seated and engaged in educational activities.	• Interventions: - Experimental group: standing on a modified tilt table for 30 minutes. - Control group: seated for 30 minutes.
Outcome	• ROM of dorsiflexion,	• MAS	• Muscle activations, video	• EMG readings pre,

Measures	muscle length in dorsiflexion, • Assessed pre and post intervention.	• Assessed pre treatment, post treatment and forty-five minutes after.	analysis, Spastic Locomotor Index, 8 metre walk. • Compared pre and post intervention	during and post intervention. • Repeated on some children at 25 (number: 18) and 35 minutes (number: 14) after.
Findings	• Maximum muscle length increased during stretches. • Elongation of muscle by 0.8cm, muscle fascicle by 0.6cms and tendon by 1.0cm. • Approximate 10° increase in dorsiflexion. Significant changes were independent of stretching technique used.	• No significant difference in muscle tone on the MAS measured immediately or 45 minutes after treatment. • In both the experimental and control group.	• Significantly decreased tibialis anterior activation post stretch, in 0-16% of the gait cycle. • No other statistically significant differences. • No systematic changes in gait pattern after treatment.	• Significant reductions in spasticity in the ankle muscles. • Capacity to voluntarily activate the plantar-flexors was significantly improved. • The capacity to activate the dorsiflexors was not affected. • These effects lasted 35 minutes post stretch.
Strengths	**Validity** - Thorough and current literature review. - Theoretical rationale. - Study design minimises carry-over effect. - Appropriate measurement techniques. - Completed in one day	**Validity** - Appropriate study design. - Clear research aim. - Specific eligibility criteria. - Similar experimental and control groups. - Theoretical rationale. - Random recruitment and assignment method. - Identical treatment of	**Validity** - Appropriate study design. - Specific eligibility criteria. - Theoretical rationale. - Identical treatment of groups apart from the intervention. - Differences between groups - statistical analysis found non-significant	**Validity** - Appropriate study design. - Theoretical rationale. - Specific eligibility criteria. - Identical treatment of groups apart from the intervention. - Very objective measurements. - Reasoning for incomplete

	at one clinic. - Specific eligibility criteria. - Randomised order of techniques - No participant dropout. - Thorough data collection and analysis - Two ANOVA's, paired t-tests and computer analysis. - Discussion of limitations and impact on further research and practice. - Free of selective reporting. - Results supported by recent research. **Reliability** - Pilot study. - Ethical approval - Consent gained. - One physiotherapist applying and guiding all treatments. - Discusses risk of carryover effect and	groups apart from the intervention. - Relevant outcome measures. - Use of statistical tests to compare groups and SPSS software. - No participant drop out. - Results analysed in the intervention groups. - Findings supported with current research. - Free of selective reporting. **Reliability** - Ethical approval. - Limitations of study discussed. - Consent gained. - Answered research question.	impact. - Mean age, height and weight very similar between groups. - Wide range of outcomes. - All clinically relevant outcomes reported. - Results functionally analysed in the intervention groups. - No participant dropout. - Use of statistical tests. - Findings supported with contemporary research for the paper. - Free of selective reporting. - Discussion of need for future research. - Some discussion of limitations. **Reliability** - Consent gained. - Wide range of references. - Answered research question.	data. - Two different statistical analyses. - Issues in assignment factored into data analysis. - Intention to treat analysis. - Results analysed in treatment groups. - Discusses impact on practice. - Findings supported with contemporary research for the paper. - Free of selective reporting. - All clinically relevant outcomes reported. - Highlighted clinical importance. **Reliability** - Pilot study. - Ethical approval gained. - Consent gained. - Answered research question. - Wide range of references used.

	their minimisation. - Wide range of references. - Answered research question.			
Weaknesses	**Validity** - No confidence levels. - No control over other confounding factors. Generalizability: - Small sample size. Selection bias: - Geographic location of participant recruitment not discussed. - No allocation concealment. Performance bias: - No blinding. - Medial gastrocnemius fascicle length quantified in 6/8 participants with no reasoning. **Reliability** - Short duration of study. - Little discussion of the validity, precision and	**Validity** - One outcome measure studied. - No confidence intervals. - MAS - lack of sensitivity. - Limited discussion of results. - No control over other confounding factors. Generalizability: - Small sample size. - No recognition of impact on research or clinical practice. Selection bias: - No discussion of the geographic area of recruitment. - Lack of detail of random sampling techniques. - No allocation concealment. Performance bias: - No blinding.	**Validity** - Age of study. - No confidence levels. - No control over other confounding factors. Generalizability: - Recruitment from a small geographic area. - Small sample size. Selection Bias: - No allocation concealment. - Same participants as Tremblay et al. (1990). Performance Bias: - No blinding. **Reliability** - No discussion of ethical approval. - No discussion concerning the scheduling of the participant testing. - No discussion of	**Validity** - Age of study. - No control over other confounding factors. - No confidence levels. Generalizability: - Small sample size. - Imbalance of plegias. - Recruitment from a small geographic area. Selection Bias: - No allocation concealment. Attrition bias: - Data analysis on select sample only. - Not all participants able to complete voluntary contraction tests. Performance Bias: - No blinding of participants, therapists or assessors. **Reliability**

	reliability of processes used.	- No information on the assessors experience, blinding and involvement in research. **Reliability** - Different treatment protocols outlined throughout study. - No description of the setting of the study. - Short duration of study. - No explanation of use of MAS. - Limited explanation of control intervention. - No discussion of the validity, precision and reliability of the processes. - Small range of references. - No pilot study conducted.	environment. - Short duration of study. - No pilot study. - No discussion of the validity, precision and reliability of the processes used.	- No discussion of environment. - No discussion on the reliability and validity of the tools used. - No discussion of limitations. - Short duration of study.

Diagrams from Text

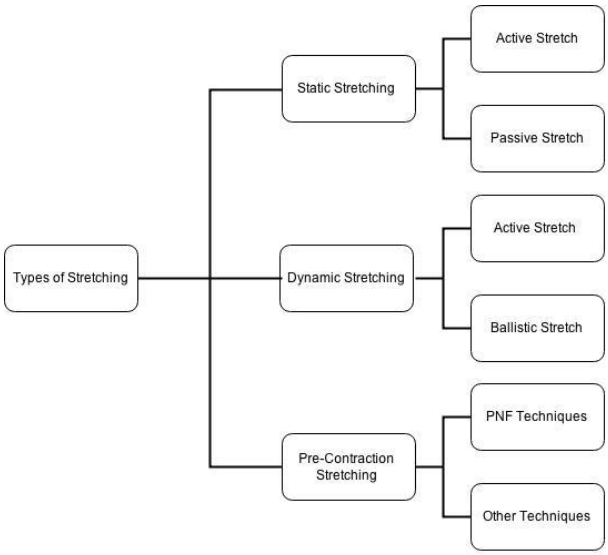
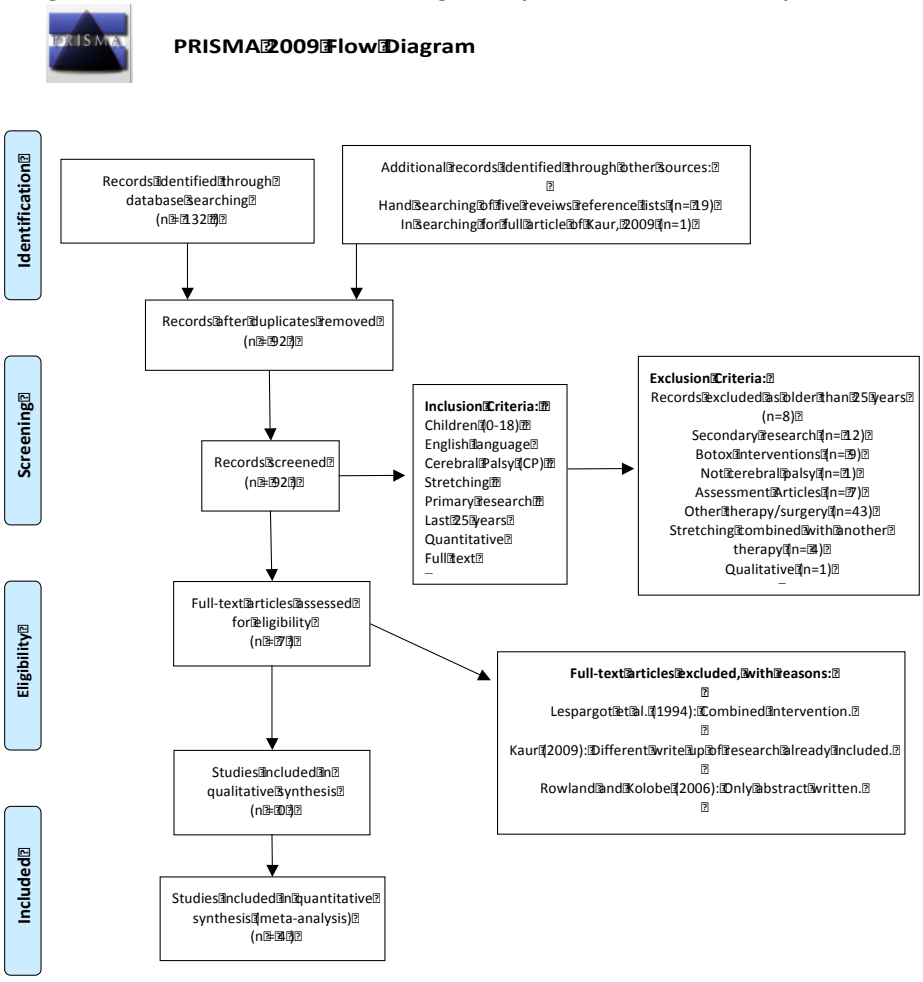


Diagram one: different types of stretching (Page, 2012).

Diagram two: PRISMA flow diagram (Moher et al., 2009).



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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