MODULATION OF MUSCLE TIGHTNESS BY MANUAL STRETCHING IN CHILDREN WITH SPASTIC CEREBRAL PALSY (A SYSTEMATIC REVIEW)

Thesis
Submitted in Partial Fulfillment for the Requirements of Master Degree in Physical Therapy

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ABSTRACT

Objective: The aim of this work was to systematically review the studies which assess the effects of manual stretching on muscle tightness in children with spastic cerebral palsy

Methods: Systematic review of all published studies with all research designs except expert opinions. A search was made in Medline, Cochrane library, PEDro and Google scholar; from the earliest date to September 2010

Intervention: Passive manual stretching programs performed by the physical therapist in children diagnosed as cerebral palsy with age between birth to eighteen years

Outcome measures: Passive joint range of motion.

Results: Only 4 studies met the inclusion criteria. Meta-analysis could not be done and findings are presented qualitatively due to heterogeneity of the studies. There is conflicting evidence on whether passive stretching can increase the range of movement in a joint. One study showed no difference poststretching, but three studies showed some improvements in the range of movement. For those studies showing improvements in the range of movements, the effect sizes were fairly small (in general less than 10°). All studies are of poor methodological quality except one study of high quality.

Conclusion: The current level of evidence to support the effectiveness of passive manual stretching in children with spastic cerebral palsy remains weak.

Key words: Systematic Review, Cerebral Palsy, Stretching, Range of Motion and Spasticity.
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<td>American Academy for Cerebral Palsy and Developmental medicine</td>
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<td>ABABA, ABCBCBA, ABBAAB</td>
<td>Variations of single subject research design in which the order of an experimental treatment (B), a placebo (C) or a baseline treatment (A) is randomly allocated.</td>
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<tr>
<td>BtA</td>
<td>Botulinum toxin type A</td>
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<td>CI</td>
<td>Confidence interval</td>
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<td>PEDro</td>
<td>Physiotherapy Evidence Database</td>
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<td>PROM</td>
<td>Passive range of motion</td>
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<td>Pubmed</td>
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<td>RCTs</td>
<td>Randomized controlled trials</td>
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CHAPTER I
INTRODUCTION

A systematic review is the application of scientific strategies that limit bias by the systematic assembly, critical appraisal and synthesis of all relevant studies on a specific topic (Manchikanti, 2008).

A Systematic review is a "study of studies". All relevant research is analyzed in an effort to determine the overall evidence for an intervention. A systematic review is a literature review focused on a single clear question which tries to identify, select and appraise all high quality research evidence relevant to that question then makes assessment of the included studies and synthesis of findings and interpretation. Systematic reviews are generated to answer specific, often narrow, clinical questions in depth (Garg et al., 2008).

Cerebral palsy (CP) is the commonly used name for a group of conditions characterized by motor dysfunction due to non-progressive brain damage early in life. There are usually associated disabilities as well as emotional and social family difficulties. The range of severity may be from total dependency and immobility to abilities of talking, independent self-care and walking, running and other skills although with some clumsy actions (Levitt, 2004).

In developed nations, the incidence of cerebral palsy is about 1 to 2 per 1000 living births (Berker and Yalcin, 2005). In most cases of cerebral palsy, the etiology remains unknown or unproven. Cerebral palsy can be of prenatal, perinatal or postnatal origin (Wolraich, 2003).
The classification of the subtypes of cerebral palsy is based upon clinical determinations of movement disorder that may change presentation as the child grows and develops. This movement disorder is topographically classified by the number of limbs impaired into, hemiplegia (limbs on one side affected), diplegia (four limbs are involved, with arms much less affected than legs) and quadriplegia (all limbs are involved), and by symptoms of impairment cerebral palsy is classified into spastic, dyskinetic and a rare ataxic type (Levitt, 2004).

Cerebral palsy presents with "impairments" in body function and structure such as muscle tone, strength, reflexes and range of motion. Significant "activity" limitations can also be present (e.g. dressing, feeding and functional mobility) as well as restricted "participation" (e.g. playing and participating in school) in social and community roles for the child (Law, 2007).

Children with cerebral palsy (CP) are functionally limited to varying degrees because of their decreased central control and coordination of their movements. The effects of growth predispose children with neurological impairments to the secondary problems of muscle contractures, bony deformities, and unusual gait abnormalities. Health care programs aim to prevent deformities and encourage the development of functional and independent skills and abilities (Seymour, 2002).

Passive stretching is widely used for individuals with spasticity in a belief that tightness or contracture of soft tissues can be corrected and lengthened. Evidence for the efficacy of passive stretching on individuals with spasticity is limited (Pin et al., 2006).
Statement of the problem:

The research question in this systematic review is "Does manual stretching improves muscle tightness in children with spastic cerebral palsy?"

Purpose of the study:

The purpose of this study is to systematically review the studies which assess the effects of manual stretching on muscle tightness in children with spastic cerebral palsy.

Significance of the study:

Evidence based medicine is needed to improve quality of health care. A body of evidence regarding safety, effectiveness, appropriate indications, cost-effectiveness, and other attributes of medical care are demanded (Manchikanti, 2008).

We live in the information age; the number of published studies in the biomedical literature has dramatically increased. Because even highly cited trials may be challenged over time, clinical decision-making requires ongoing reconciliation of studies that provide different answers to the same question. Because it is often impractical for readers to track down and review all of the primary studies, review articles are an important source of summarized evidence on a particular topic (Garg et al., 2008).

Physical therapists have to use the evidence in practice to improve the quality of patient care and to ensure that the best update of treatment is delivered. However, incorporating research into practice is time consuming, and so we need methods of facilitating easy access to evidence for busy clinicians, systematic reviews aim to inform and facilitate this
process through research synthesis of multiple studies, enabling increased and efficient access to evidence.

Passive stretching is a common treatment to combat soft tissue tightness. The stretching can be done manually by the therapist or the patient or by other external devices such as splints, casts, or tilt-table. Despite the widespread use of passive stretching, there is a lack of research evidence demonstrating its effectiveness and the rationale behind the stretch-based techniques in spastic human muscles (Gracies, 2001).

A survey was done in Canada among parents of children with CP demonstrated that stretching was the daily living activity most frequently identified as painful by parents (93% of those reporting pain), and the one with the highest mean pain intensity. (Hadden and von Baeyer, 2002).

This systematic review is a trial to fill the gap of knowledge between research and clinical practice in using manual stretching in the rehabilitation of cerebral palsy.

**Delimitation:**

The study was delimited to:

- All studies except expert opinions.
- Children with spastic cerebral palsy from birth to 18 years of age.
- Published manuscripts in any language.

**Limitations:**

- Few numbers of randomized controlled trials related to the topic.
- Limitation of research to published studies only.
- One person only reviewing the studies.
CHAPTER II
REVIEW OF LITERATURE

This chapter included the following items:

1- Evidence based medicine
2- Systematic review
3- Cerebral palsy
4- Muscle tightness and muscle contracture
5- Passive stretching

I) Evidence-based medicine:

Evidence-based medicine was initially called “critical appraisal” to describe the application of basic rules of evidence as they evolve into application in daily practices. Evidence-based medicine is defined as an explicit and judicious use of current best evidence in making decisions about the care of individual patients. Evidence-based practice is defined based on 4 basic and important events, which include recognition of the patient’s problem and construction of a structured clinical question, thorough search of medical literature to retrieve the best available evidence to answer the question, critical appraisal of all available evidence, and integration of the evidence with all aspects and contexts of the clinical circumstances (Manchikanti, 2008).

Evidence-based practice - as shown in figure (1)- involves "integration of best research evidence with clinical expertise and patient values". It is a process that involves more than knowledge of current research (Sackett et al., 2000).
Decision-making is the process by which evidence is (or is not) applied to practice. The statement "evidence alone does not make decisions, people do" reflects the integral role of the therapist in translation of evidence to practice. Therapists make decisions on complex issues related to examination, prognosis, expected outcomes, the plan of care, and coordination of care on a daily basis (Haynes et al., 2002).

**Hierarchy of Evidence:**

Evidence generated from research is not all the same. Some evidence is better than others. As shown in figure (2), one should start looking for the best available one (in descending order of importance) which is obtained from:

- Systematic reviews (SR) and meta-analysis of randomized controlled trials.
- Randomized controlled studies (RCTs).
- Non-randomized controlled studies.
- Cohort studies.
- Case control studies.
• Case series.
• Case reports.
• Opinions of experts or respected authorities.
• Animal research and in vitro studies.  \textit{(Sackett et al., 2000)}

\textbf{Figure (2): Levels of Evidence. (Sackett et al., 2000)}

Systematic reviews and meta-analysis lie on top of the evidence pyramid both in public health and clinical medicine \textit{(Abdel-Raouf and Attia, 2007)}.

Although the results of a randomized controlled trial (RCT) provide the strongest evidence of cause and effect relationship between the intervention and outcomes, trials are often difficult to implement with children with developmental disabilities \textit{(Campbell et al., 2006)}. 
Appraisal of the evidence includes assessment of the relevance and validity of the evidence and finally the evidence is integrated with clinical experience and patient values before applying it to the patient (Attia, 1999).

The amount of evidence supporting or failing to support the effectiveness of physical therapy for children with cerebral palsy has increased exponentially in each of the past 2 decades. Reasons for this include (1) academic progress within the physical therapy profession, including a greater number of PhD-trained therapists and elevation of the basic education level for therapists from a bachelor’s to a doctoral degree and (2) factors outside of the profession, such as a greater focus on evidence-based practice in all medical and allied health fields and increased pressure from third-party payers to demonstrate efficacy of therapies (Damiano, 2009).

It is unethical for the therapists not to base practice on the best medical evidence (Flett and Stoffell, 2003).

Requirements for evidence-based physical therapy:

- A willingness to challenge one's assumptions.
- The ability to develop relevant clinical questions about a patient/client.
- Access to evidence.
- Knowledge regarding evidence appraisal.
- The time to make it all happen.

(Jewell, 2008)
II) Systematic review:

Systematic review is a scientific tool that can be used to appraise, summarize, and communicate the results and implications of otherwise unmanageable quantities of research (Cook et al., 1997).

As their name implies, systematic reviews are the antithesis of the narrative review and are located at the top of most evidence hierarchies. A systematic review is a true research paper with the following design elements and controls:

1. A specific research question to be addressed.
2. Detailed inclusion and exclusion criteria for selection of studies to review.
3. Elaborate and thoughtful search strategies.
4. Standardized review protocols that often include trained reviewers other than the primary investigators.
5. Standardized abstracting processes for capturing details about each study included in the review.
6. Preestablished quality criteria with which to rate the value of the individual studies, usually applied by masked reviewers.

(Jewell, 2008)

Importance of systematic reviews:

For busy healthcare providers and decision makers, systematic reviews are important as they summarize the overwhelming amount of research – based healthcare information that is available to be read and synthesized (Clarke, 2005).
They also overcome some of the bias associated with small single trials where results may not be robust against chance variation if the effects being investigated are small (*Glasziou et al., 2004*).

### III) Cerebral palsy:

**Definition:**

Cerebral palsy is a term used to describe a group of disorders of movement, muscle tone, or other features that reflect abnormal control over motor function by the central nervous system. It encompasses only those non-progressive or static lesions that affect the control of developing brain over motor abilities (*Wolraich, 2003*).

**Etiology:**

Cerebral palsy can be of prenatal origin, secondary to such conditions as the following: (1) congenital brain malformations, (2) neuronal migration disorders, (3) vascular disturbances, (4) genetic syndromes, (5) maternal infections, and (6) other maternal factors. Common peri-and post natal causes include (1) trauma, (2) asphyxia, (3) infections, and (4) cerebral hemorrhage (*Wolraich, 2003*).

**Incidence:**

Cerebral palsy is a chronic disabling condition of childhood. It occurs in 1.5/1,000 to 3/1,000 live births with spasticity as a prevalent disabling clinical symptom. The incidence is higher in males than in females (*Volpe, 2008*).
*Classification:*

**Topographical classification:**

- Tetraplegia (quadriplegia): Involvement of all limbs. Arms are equally or more affected than the legs. Many are asymmetrical (one side more affected) and called double hemiplegia.
- Diplegia: Involvement of limbs, with arms much less affected than legs.
- Hemiplegia: Limbs on one side affected.

*(Macnair and Hicks, 2011)*

**Classification of types of cerebral palsy:**

There are several different types of cerebral palsy. While some patients are severely affected, others have only minor disruption, depending on which parts of the brain have been damaged. The main types of cerebral palsy are:

- Spastic cerebral palsy - some of the muscles in the body are tight, stiff and weak, making control of movement difficult.
- Athetoid (dyskinetic) cerebral palsy - control of muscles is disrupted by spontaneous and unwanted movements. Control of posture is also disrupted.
- Ataxic cerebral palsy - problems include difficulty with balance, shaky movements of hands or feet, and difficulty with speech.
- Mixed cerebral palsy - a combination of two or more of them.

*(Macnair and Hicks, 2011)*
*Treatment:*

There is no cure for CP, however, various forms of therapy can reduce the impact of the condition by easing symptoms such as spasticity, improving communication skills and finding other ways to do things. Treatment may include one or more of the following: physical therapy; occupational therapy; orthoses; speech therapy; drugs; hyperbaric oxygen; biofeedback; surgery to correct anatomical abnormalities or release tight muscles; and botulinum toxin A (BtA) *(Wikipedia, 2010).*

- Physical therapy (PT) programs are designed to encourage the patient to build a strength base for improved gait and volitional movement, together with stretching programs to limit contractures.
- Occupational therapy helps adults and children maximize their function, adapt to their limitations and live as independently as possible.
- Orthotic devices are often prescribed to minimize gait irregularities, control spasticity, tightness and deformities.
- Speech therapy helps control the muscles of the mouth and jaw, and helps improve communication.
- Hyperbaric oxygen therapy significant enhancements were documented showing improved vision, hearing and speech as well as a reduction of spasticity.
- Biofeedback is an alternative therapy in which people with CP learn how to control their affected muscles.
- Surgery usually involves one or a combination of:
  - Loosening tight muscles and releasing fixed joints.
  - Straightening abnormal twists of the leg bones.
  - Cutting nerves on the limbs most affected by movements and spasms.

*(Wikipedia, 2010)*
IV) Muscle tightness and muscle contracture:

Restricted motion can range from mild muscle shortening to irreversible contractures. Contracture is defined as the adaptive shortening of the muscle-tendon unit and other soft tissues that cross or surround a joint that results in significant resistance to passive or active stretch and limitation of ROM, and it may compromise functional abilities *(Kendall et al., 2005).*

There is no clear delineation of how much limitation of motion from loss of soft tissue extensibility must exist to designate the limitation of motion as a contracture. In one reference, contracture is defined as an almost complete loss of motion, whereas the term shortness is used to denote partial loss of motion. The same resource discourages the use of the term tightness to describe restricted motion due to adaptive shortening of soft tissue despite its common usage in the clinical and fitness settings to describe mild muscle shortening *(Kendall et al., 2005).*

However, another resource uses the term muscle tightness to denote adaptive shortening of the contractile and noncontractile elements of muscle *(Hertling and Kessler, 2006).*

*Types of Contractures:*

One way to clarify what is meant by the term contracture is to describe contractures by the pathological changes in the different types of soft tissues involved *(Cummings et al., 1983).*

1) Myostatic Contracture

In a myostatic (myogenic) contracture, although the musculotendinous unit has adaptively shortened and there is a significant loss of ROM, there is no specific muscle pathology present. From a
morphological perspective, although there may be a reduction in the number of sarcomere units in series, there is no decrease in individual sarcomere length. Myostatic contractures can be resolved in a relatively short time with stretching exercises (Cummings et al., 1983).

2) Pseudomyostatic Contracture

Impaired mobility and limited ROM may also be the result of hypertonicity (i.e., spasticity or rigidity) associated with a central nervous system lesion such as a cerebral vascular accident, a spinal cord injury, or traumatic brain injury (Cummings et al., 1983).

Muscle spasm or guarding and pain may also cause a pseudomyostatic contracture. In both situations the involved muscles appear to be in a constant state of contraction, giving rise to excessive resistance to passive stretch. Hence, the term pseudomyostatic contracture or apparent contracture is used. If inhibition procedures to reduce muscle tension temporarily are applied, full passive elongation of the apparently shortened muscle is then possible (Cherry, 1980).

3) Arthrogenic and Periarticular Contractures

An arthrogenic contracture is the result of intra-articular pathology. These changes may include adhesions, synovial proliferation, joint effusion, irregularities in articular cartilage, or osteophyte formation (Euhardy, 1999). A periarticular contracture develops when connective tissues that cross or attach to a joint or the joint capsule lose mobility, thus restricting normal arthrokinematic motion (Kisner and Colby, 2007).

4) Fibrotic Contracture and Irreversible Contracture

Fibrous changes in the connective tissue of muscle and periarticular structures can cause adherence of these tissues and subsequent
development of a fibrotic contracture. Although it is possible to stretch a fibrotic contracture and eventually increase ROM, it is often difficult to reestablish optimal tissue length (*Kisner and Colby, 2007*).

Permanent loss of extensibility of soft tissues that cannot be reversed by nonsurgical intervention may occur when normal muscle tissue and organized connective tissue are replaced with a large amount of relatively nonextensible, fibrotic adhesions and scar tissue or even heterotopic bone. These changes can occur after long periods of immobilization of tissues in a shortened position or after tissue trauma and the subsequent inflammatory response. The longer a fibrotic contracture exists or the greater the replacement of normal muscle and connective tissue with nonextensible adhesions and scar tissue or bone, the more difficult it becomes to regain optimal mobility of soft tissues and the more likely it is that the contracture will become irreversible (*Cummings and Tillman, 1992*).

**Mechanisms of Muscle Contracture in Children with CP:**

Increased muscle tone and poor selective motor control affect many children with CP and both of these impairments may contribute to decreased frequency and variety of voluntary movement (*Wilson-Howle, 1999*).

It is assumed that reduced movement contributes to a decrease in muscle belly length due to an adaptive response of the muscle involving a reduction in the number of in-series sarcomeres (*Lieber et al., 2004*).

However, little is actually known about the structural and mechanical changes that occur within the muscles of children with spasticity. Knowledge about the physiological mechanisms involved in contracture
development has the potential to inform intervention strategies used in pediatric physical therapy (Wiart et al., 2008).

Traditional theories of muscle contracture development were based on classic animal model studies performed in the 1970s by a group of researchers in France (Tardieu et al., 1973).

These researchers evaluated differential responses of cat and rodent muscles to immobilization in different positions. When the soleus muscles in these animal models were immobilized in a shortened position, the muscles adapted by a shortening of the muscle fibers because of a significant reduction (up to 40%) in the number of in-series sarcomeres. When the soleus muscles were immobilized in elongated positions, the muscles adapted by increasing the number of in-series sarcomeres (Tabary et al., 1972).

These studies provided evidence that the soleus muscles of these animals responded to joint immobilization by modifying the number of in-series sarcomeres. The results of these animal model studies have been extrapolated to explain human muscle response to immobilization, but there has not been rigorous evaluation of the assumption that human muscles respond similarly to the animal models (Lieber et al., 2004).

In a well-known study with children with CP, increased muscle hypoextensibility (resistance to passive stretch) was observed in the triceps surae muscles compared with muscles of typically developing children and concluded that decreased muscle extensibility was the result of the adaptive response (i.e., reduction of the number of in-series sarcomeres) observed in the animal models. They did not, however, directly measure either muscle fiber length or the number of sarcomeres to confirm this theory of muscle contracture (Tardieu et al., 1982).
The only definitive method of determining muscle fiber length is to dissect fibers from whole muscles. For obvious reasons, this invasive technique is not used with humans (Lieber et al., 2004).

Alternate methods have been developed to measure muscle fiber length in spastic muscles of children with CP. An intraoperative laser diffraction technique was used to compare the sarcomere length of the flexor carpi ulnaris muscles of individuals with wrist flexion contractures (ie, 5 children with CP and 1 adult with spasticity) and 12 participants without disabilities. The study data suggested that sarcomere length of the individuals with spasticity was increased whereas serial sarcomere number and muscle fiber length were not different from the control group (Lieber and Friden, 2002).

Ultrasound has also been used to measure muscle fiber length of children with CP (Shortland et al., 2002 and Mohagheghi et al., 2007).

The muscle thickness and deep fascicle angle (angles at which fascicles arise from the deep aponeurosis) of the medial gastrocnemii muscles were measured in 5 adults without disabilities (24 to 36 years), 7 children with spastic diplegic CP (6 to 13 years), and 5 children without disabilities (7 to 11 years). Deep fascicle angles of the children with spastic diplegia were reduced significantly compared with the control group, but the actual muscle fiber length did not differ between the two groups (Shortland et al., 2002).

Both of these studies, Lieber and Friden,(2002) and Shortland et al.,(2002), suggest that the underlying mechanism of muscle contracture is not a reduction of in-series sarcomeres.
It was hypothesized that the gastrocnemii muscle bellies are shortened in individuals with CP because of muscle fiber atrophy rather than decreased sarcomere length or decreased number of in-series sarcomeres. Because the gastrocnemius is a pinnate muscle composed of fibers that run at an angle to the force generated, a decrease in muscle fiber diameter could conceivably contribute to muscle belly shortening (Shortland et al., 2002).

The other study used the same ultrasound technique and found that gastrocnemii muscle thickness was reduced in the involved legs compared with the uninvolved legs of 8 children with spastic hemiplegia (Mohagheghi et al., 2007).

However, in contrast to Shortland et al., (2002), it was reported by Mohagheghi et al., (2007) that muscle fascicle lengths were reduced in the involved legs. The authors concluded that their data may support a reduction of both in-series and in parallel sarcomeres in the involved gastrocnemii of children with spastic hemiplegia.

Our understanding regarding the mechanism of contracture in spastic muscles is limited. The studies reviewed here suggest different underlying mechanisms of muscle shortening: reduction of the number of in-series sarcomeres, reduction of in-parallel sarcomeres, and muscle fiber atrophy. The traditional theory that decreased movement causes muscle shortening by reduction of the number of in-series sarcomeres supports classic stretching of the muscles, whereas the explanation of muscle fiber atrophy would indicate the use of muscle strengthening techniques to prevent or reduce contractures. If muscle fiber atrophy is associated with muscle contracture, resistance training and electrical stimulation will need to be explored as strategies for contracture treatment. More information is
needed about the mechanisms of muscle contracture to guide selection of the most appropriate intervention choices (Wiart et al., 2008).

V) Passive stretching:

Stretching is defined as "any therapeutic maneuver designed to lengthen (elongate) pathologically shortened soft tissue structures, thereby increasing the range of motion". Passive stretching is defined as "type of mobility exercise in which manual, mechanical or positional stretch is applied to soft tissues and in which the force is applied opposite to the direction of shortening" (Kisner and Colby, 2007).

How the intervention might work:

To understand how stretch might work it is important to highlight the difference between the transient and lasting effects of stretch. The transient effects of stretch have been extensively examined in animals and humans, with and without contractures. Animal studies have shown immediate increases in the length of soft tissues with stretch (Taylor et al., 1990).

Human studies have demonstrated similar findings, with immediate increases in joint range of motion and decreases in resistance to passive joint movement (Bohannon, 1984; Magnusson et al., 1995; Magnusson et al., 1996 and Duong et al., 2001). This phenomenon is termed viscous deformation (Magnusson et al., 1995; Weppler and Magnusson, 2010). Importantly, the effects of viscous deformation only last briefly once the stretch is removed (Duong et al., 2001).

The lasting effects of stretch are more important than any transient effects for the treatment and prevention of contractures. Unfortunately, the mechanisms underlying any possible lasting effects of stretch are less understood. Current knowledge is based on animal studies which indicate
that soft tissues undergo structural adaptations in response to regular and intensive stretch (Tabary et al., 1972 and Goldspink et al., 1974). These studies have primarily examined the effect of stretch on sarcomeres, the basic units of muscle. For example, studies on animal muscles have shown that four weeks of sustained stretch increases the number of muscle sarcomeres that are in series (Tabary et al., 1972), with sarcomere numbers returning to normal four weeks after the last stretch (Goldspink et al., 1974). Further animal studies have also suggested that only 30 minutes of stretch per day is required to prevent loss of sarcomeres in series (Williams 1990). Thus it would appear that animal muscles are highly adaptable in response to stretch.

On one level the results of animal studies appear to be consistent with observations in humans, suggesting that stretch induces lasting changes in joint range of motion and soft tissue extensibility. For example, the extreme extensibility of yoga enthusiasts and ballerinas is often attributed to the intensive stretch routines performed by these individuals. Furthermore, a large number of human studies (many non-randomized) also indicate that stretch increases joint range of motion and soft tissue extensibility (Leong, 2002 and Decoster et al., 2005). However, these observations and results are not based on high quality evidence and in some cases any apparent effects may be solely due to poor terminology (Weppler and Magnusson, 2010). Consequently, there is uncertainty and controversy about the effectiveness of stretch for the treatment and prevention of contractures in clinical populations.

Contraindications to Stretching:

- A bony block that limits joint motion.
- Recent fracture, and bony union is incomplete.
• Evidence of an acute inflammatory or infectious process (heat and swelling) or soft tissue healing could be disrupted in the tight tissues and surrounding region.

• Sharp, acute pain with joint movement or muscle elongation.

• A hematoma or other indication of tissue trauma.

• Hypermobility already exists.

• Shortened soft tissues provide necessary joint stability in lieu of normal structural stability or neuromuscular control.

• Shortened soft tissues enable a patient with paralysis or severe muscle weakness to perform specific functional skills otherwise not possible.

(Kisner and Colby, 2007)

Muscle contractures contribute to loss of joint range of motion and decreased functional movement for children with a diagnosis of cerebral palsy (Pirpiris and Graham, 2001).

Stretching programs are an important component of physical therapy intervention with this group of children. The use of muscle stretching is based on the assumptions that stretching will increase muscle extensibility, preserve joint range of motion for functional movement, and prevent or delay the need for orthopedic surgical interventions (Olney and Wright, 2000).

The primary outcome evaluated in studies examining the effects of passive stretching in individuals with CP has been joint range of motion. Goniometric measurements are appropriate because the primary outcome expected with stretching is a change in muscle length and joint range of motion (Wiart et al., 2008).
Despite the widespread use of stretching as a physical therapy management strategy for children with CP, knowledge about the effectiveness of stretching techniques is limited for two reasons. First, the mechanisms and etiology of muscle contractures in children with CP are not well understood, making it difficult to determine if the theory underlying muscle stretching is correct. Second, clinical research evaluating the effectiveness of stretching techniques with children with CP is inconclusive and cannot guide therapists’ clinical decision making (Wiart et al., 2008).

**Previous systematic reviews about stretching for cerebral palsy:**

Two systematic reviews have recently been published examining the effect of passive stretching to improve range of motion or to affect spasticity in children with CP (Pin et al., 2006) and (Wiart et al., 2008).

*Pin et al. (2006)* identified 10 studies, of which, four were RCTs on the topic. Overall, the authors reported limited evidence for passive stretching to improve range of motion. The authors reported some evidence for increased range of movement following stretching and decreased
spasticity, but no lasting effect. Sustained stretching was preferred to manual stretching.

*Wiart et al. (2008)* reported on seven studies with three RCTs and the paper overlapped the findings of Pin and colleagues (2006). The RCTs from both reviews are listed in Table 1. The findings of Wiart also reported limited evidence for passive stretching, active stretching or for positioning to improve range of motion in children with CP.

**Table (1): The previous randomized controlled trials from previous systematic reviews about stretching for cerebral palsy:**

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Miedaner &amp; Renander, 1987)</td>
<td>Passive stretching</td>
</tr>
<tr>
<td>(O’Dwyer et al, 1994)</td>
<td>Passive stretching</td>
</tr>
<tr>
<td>(Richards et al, 1991)</td>
<td>Single prolonged stretch</td>
</tr>
<tr>
<td>(Tremblay et al, 1990)</td>
<td>Single prolonged stretch</td>
</tr>
</tbody>
</table>

A very recent, well-designed systematic review demonstrated that there is high quality evidence to indicate that stretch does not have clinically important short-term (one to seven days) or long-term (> one week) effects on joint mobility in people with neurological conditions with, or at risk of, contractures (*Katalinic et al., 2010 and Katalinic et al., 2011*).
CHAPTER III
METHODOLOGY

Search Strategy for Identification of Studies:

Electronic database search was performed from the earliest date to September 2010 to identify relevant articles in:

- The Cochrane Library at http://www.thecochranelibrary.com
- Physiotherapy Evidence Database (PEDro) at http://www.pedro.org.au/
- Google scholar at http://scholar.google.com.eg

The following key words were used in the search:

- "Cerebral palsy"
- "Stretching"
- "Muscle spasticity"
- "Contracture"
- "Range of motion"
- "Physical therapy"

Table (2): Search results:

<table>
<thead>
<tr>
<th>Search strategy</th>
<th>PubMed results</th>
<th>Cochrane results</th>
<th>PEDro results</th>
<th>Google results</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 &quot;Cerebral palsy&quot; AND stretching</td>
<td>48</td>
<td>53</td>
<td>10</td>
<td>6550</td>
</tr>
<tr>
<td>#2 &quot;Cerebral palsy&quot; AND Contracture</td>
<td>403</td>
<td>18</td>
<td>6</td>
<td>4960</td>
</tr>
<tr>
<td>Search strategy</td>
<td>PubMed results</td>
<td>Cochrane results</td>
<td>PEDro results</td>
<td>Google results</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td>#3 &quot;Cerebral palsy&quot; AND &quot;Range of motion&quot;</td>
<td>542</td>
<td>108</td>
<td>16</td>
<td>8110</td>
</tr>
<tr>
<td>#4 &quot;Cerebral palsy&quot; AND &quot;Physical therapy&quot;</td>
<td>1031</td>
<td>248</td>
<td>36</td>
<td>13800</td>
</tr>
<tr>
<td>#5 &quot;Cerebral palsy&quot; AND stretching AND &quot;Muscle spasticity&quot; AND Contracture AND &quot;Range of motion&quot;</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>#6 &quot;Cerebral palsy&quot; AND stretching AND &quot;Muscle spasticity&quot; AND Contracture AND &quot;Physical therapy &quot;</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>236</td>
</tr>
<tr>
<td>#7 &quot;Cerebral palsy&quot; AND stretching AND &quot;Muscle spasticity&quot; AND &quot;Range of motion&quot; AND &quot;Physical therapy &quot;</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>276</td>
</tr>
<tr>
<td>#8 &quot;Cerebral palsy&quot; AND stretching AND Contracture AND &quot;Range of motion&quot; AND &quot;Physical therapy &quot;</td>
<td>29</td>
<td>3</td>
<td>0</td>
<td>820</td>
</tr>
<tr>
<td>#9 &quot;Cerebral palsy&quot; AND &quot;Muscle spasticity&quot; AND Contracture AND &quot;Range of motion&quot; AND &quot;Physical therapy &quot;</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>272</td>
</tr>
<tr>
<td>#10 All keywords combined</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>199</td>
</tr>
</tbody>
</table>

Reference lists in the relevant studies and review articles were examined.
Study Selection Criteria:

The titles and abstracts collected by the above mentioned search strategy, were initially screened against the inclusion and exclusion criteria for identification of the relevant trials. When the title and abstract did not indicate clearly if an article should be included, the complete article would be read to determine its suitability.

- Inclusion criteria

- Types of Studies:
  
  Published full text articles in peer-reviewed journals with all research designs except expert opinions.

- Types of Participants:
  
  The review included children (from birth to 18 years of age) with spastic cerebral palsy.

- Types of Interventions:
  
  This review included studies which demonstrate the effects of passive manual stretching programs performed by the physical therapist with reported findings for analysis of its effectiveness.

- Types of Outcome Measures:
  
  Only outcome measures related to passive joint range of motion were considered in this review.

Exclusion criteria:

- Unpublished studies.
  
  - Studies that compared passive stretching programs with the effects of medications, surgery, or serial casting were excluded as
the area of interest was mainly on passive stretching without assistance from surgery and antispasticity medications.

- Studies that measured the effect of stretching on spasticity or gait parameters.
- Studies that combined stretching with other types of modalities; such as heating, therapeutic ultrasound, splinting and electrical stimulation.

Quality assessment of methodology:

All the included studies were scored on their methodological rigour with the Physiotherapy Evidence Database (PEDro) scale (PEDro, 2010). The PEDro scale examines 11 aspects of the quality of methodology:

Table (3): PEDro scale

<table>
<thead>
<tr>
<th>Criteria</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. eligibility criteria were specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated in the order in which treatments were received)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. allocation was concealed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. the groups were similar at baseline regarding the most important prognostic indicators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. there was blinding of all subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. there was blinding of all therapists who administered the therapy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Pedro scale considers two aspects of trial quality, namely the “believability” (or “internal validity”) of the trial and whether the trial contains sufficient statistical information to make it interpretable. It does not rate the “meaningfulness” (or “generalisability” or “external validity”) of the trial, or the size of the treatment effect.

The first item on the PEDro scale (the item on eligibility criteria) is related to external validity, so it does not reflect the dimensions of quality assessed by the PEDro scale. This item is not used to calculate the method score (which is why the 11 item scale gives a score out of 10).

According to the PEDro guidelines, a positive answer to each of the criteria 2 to 11 will yield one point, obtaining a PEDro score between 0 to 10.
The PEDro scale has been shown to have moderate interrater reliability (intraclass coefficient for the total score is 0.56, 95% confidence interval [CI] 0.47–0.65) \((\text{Maher et al., 2003})\).

Papers that had a PEDro score of seven or higher, would be considered 'high quality', those with a PEDro score of five or six would be considered 'moderate quality', and those with a PEDro score of four or less would be considered 'poor quality'.

The American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) evidence table of internal validity was used to grade the levels of evidence of each selected study \((\text{Butler, 2003})\). This classification of levels of evidence is a modification of Sackett’s hierarchy of levels of evidence, \((\text{Sackett et al., 2000})\) but it includes and grades single subject research design, which is increasingly common in research in the developmental disability domain.

**Table (4): The AACPDM classification of levels of evidence of internal validity:**

<table>
<thead>
<tr>
<th>Level</th>
<th>Non-empirical</th>
<th>Group Research</th>
<th>Outcomes Research</th>
<th>Single Subject Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>Randomized controlled trial All or none case Series</td>
<td></td>
<td>Number of one randomized controlled trials (N-of-1 RCTs)</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>Nonrandomized controlled trial Cohort study with concurrent control group</td>
<td>Outcomes research analytic survey</td>
<td>Multiple phases (treatment/no treatment) design Alternating treatments design Multiple baseline across subjects design</td>
</tr>
</tbody>
</table>
Explanation of some research designs:

- **N-of-1 randomized controlled trials:**

  In single subject research, treatment versus control conditions are manipulated within a single person; the order of these exposures is randomly allocated. There are several variations of the Nof-1 RCT, sometimes called a randomized cross-over trial; these include the blind cross-over trial or double blind cross-over trial.

  The difference between this and a group crossover is that there are repeated measures in multiple phases. A person frequently undergoes pairs of periods in which one period applies an experimental treatment (B) and the other applies a placebo (C) or baseline (A)—in other words, an ABABA type of design or ABCBCBA or variation. The order of these periods within each pair is randomly selected so that the
conduct of the trial may be, for example, ABBAAB. Treatment outcomes are monitored to document the effect of the condition currently being applied. These phases are repeatedly measured until the person being treated and the investigator are convinced that the treatment period is clearly different, or clearly not different. In a blind trial, the person making the outcome assessments is blind to the treatment condition; in a double blind trial, both the subject and the assessor are unaware of the treatment condition.

Although this method can also provide a group comparison when more than one subject has been studied, the focus of the published report is the individual comparisons. Alternatively, when multiple N-of-1 randomized controlled trials conducted under the same protocol have been summed and a group comparison is provided, this is called a multiple cross-over trial.

Another variation of the N-of-1 RCT is the alternating treatments design in which the subject is exposed to the treatment condition and control condition(s) in close temporal proximity. For example, a subject is assessed during a 20 minute exposure to a control condition followed by a 20 minute exposure to the treatment condition; these exposures are determined by random allocation. Yet another variation is the multiple baseline across subjects design; several subjects are assessed for differing periods of exposure to the non-treatment condition (called baseline) and then assessed during treatment exposure. The order in which subjects change from the control condition to the treatment condition is established through random allocation.
• **ABA design (withdrawal design):**

  In this study, baseline (A) is established for the outcome of interest through multiple measures made over a period of time. A treatment period (B) follows and the level or trend of the outcome is established. Finally, the treatment is withdrawn with multiple measurements made again (A) to observe whether the outcome reverses. Two opportunities to observe change between treatment and control phases are available.

• **Before and after case series without control group:**

  A case series typically consists of a single group of people who receive an intervention and are followed for a time to observe their outcomes. The outcome is measured before and after the intervention, but any rate of change is not compared directly with the rates that occurred in people who were not receiving the intervention but were otherwise comparable. In the absence of a firm base of expectancy or a control group to establish expectancy, a rate of change in a single group has little credibility. The observed rate of change may have occurred for some reason other than the intervention or may have even happened without the intervention. The single subject research equivalent of this group design is the **AB design.** In this study, the investigator makes repeated measures during a baseline phase followed by measures during an intervention phase. Only one opportunity to observe change between the treatment and control phases is available.
Data Extraction:

Data from all the included studies were summarized in the format as suggested by the American Academy for Cerebral Palsy and Developmental Medicine (AACPDM). The format includes: participants' characteristics (number in each group, target population, diagnosis and ages), intervention used, research design, level of evidence for the study, outcomes of interest and results.

The AACPDM classifies the kind of evidence according to the dimensions of disablement listed in table 5:

**Table (5): Dimensions of disability according to AACPDM:**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathophysiology</td>
<td>Interruption or interference of normal physiology and developmental processes or structures</td>
</tr>
<tr>
<td>Impairment</td>
<td>Loss or abnormality of body structure or function</td>
</tr>
<tr>
<td>Functional Limitation/Activity</td>
<td>Restriction of ability to perform activities</td>
</tr>
<tr>
<td>Disability/Participation</td>
<td>Restricted participation in typical societal roles</td>
</tr>
<tr>
<td>Societal limitation/Context Factors</td>
<td>Barriers to full participation imposed by societal attitudes, architectural barriers, social policies and other external factors</td>
</tr>
</tbody>
</table>

*(Butler, 2003)*
Data analysis:

Effect sizes with 95% CIs were calculated if raw data were available in the studies (Herbert, 2000). The effect sizes give easy understanding of how big the treatment effect is and the clinical significance of these statistically significant treatment effects can also be justified. The effect size was "the difference between the means of outcome measures of the participant and control groups". If there was no control group, the difference of the pre- and post-treatment means would be used as the participants were acting as their own controls. The 95% CI was approximated by the following formula: $3 \times \text{SD}/\sqrt{N}$ (SD, standard deviation; N, number of participants in the study). The averages of the standard deviations of the group means and the numbers of participants would be used if there were participant and control groups. This formula for calculating the effect size with 95% CI was chosen as it has been deliberately simplified for clinicians who are not experienced in complicated statistical calculations (Herbert, 2000).

Confidence interval (CI) is defined as" the range of scores within which the true score for a variable is estimated to lie within a specified probability (e.g., 90 percent, 95 percent, 99 percent)" (Jewell, 2008).
CHAPTER IV
RESULTS

Literature search results:

Only four studies met the inclusion criteria. One randomized controlled trials were made on the topic (Miedaner and Renander, 1987). No additional studies were made after the last systematic review about stretching in cerebral palsy by (Wiart et al., 2008).

Table (6): The four selected studies for this systematic review:

<table>
<thead>
<tr>
<th>Study</th>
<th>Title</th>
</tr>
</thead>
</table>

The main reasons for exclusion of the other studies were:

- They were non-intervention studies.
- They were narrative reviews.
- They did not meet the inclusion and exclusion criteria.
Methodological Quality Results:

The scoring of each study with the Physiotherapy Evidence Database (PEDro) scale is listed in Table 7. The scores of the all studies included in the study ranges from three to seven, the more the number of scores of the aspects evaluating the quality of the study, the more quality of the study.

Table (7): Methodology assessment of studies according to the Physiotherapy Evidence Database (PEDro) scale

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified eligibility criteria*</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Random allocation of participants</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Concealed allocation</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Similar prognosis at baseline</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Blinded participant</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Blinded therapists</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Blinded assessors</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>More than 85% follow-up for at least one key outcome</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>‘Intention to treat’ analysis</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Between group statistical analysis for at least one key outcome</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Point estimates of variability for at least one key outcome</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PEDro score</td>
<td>4/10</td>
<td>3/10</td>
<td>7/10</td>
<td>4/10</td>
</tr>
</tbody>
</table>

*This criteria is not counted for the total PEDro score
Table 8 summarizes the characteristics of the research participants in these four studies. The participants were aged from four to twenty years of age. As there was no raw data available in the study including participants more than 18 years of age - *(Miedaner and Renander, 1987)* - it was impossible to exclude the data relating to those participants more than eighteen years of age. This study was still included in this systematic review of the effects of manual stretching in children with CP.

**Table (8): Summary of study characteristics**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Multiple single-subject design (multiple phases design)</td>
<td>Before and after case series design</td>
<td>Multiple single-subject design (randomized cross-over design)</td>
<td>Multiple single-subject design (multiple phases design)</td>
</tr>
<tr>
<td>Level of evidence</td>
<td>II</td>
<td>IV</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Participant characteristics</td>
<td>Children with spasticity in lower limbs with classification of Levels IV and V by GMFCS</td>
<td>Children with spastic CP with spasticity in hip adductors</td>
<td>Children with severe physical and cognitive impairment and decrease in joint ranges of lower limbs</td>
<td>Children with severe spastic quadriplegic CP with knee contracture</td>
</tr>
<tr>
<td>Nr of participants</td>
<td>Treatment group</td>
<td>Control group</td>
<td>Treatment group</td>
<td>Control group</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>10</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>7*</td>
<td>20</td>
<td>13*</td>
<td>4*</td>
</tr>
<tr>
<td>Age range</td>
<td>4–18</td>
<td>9–13</td>
<td>6–20</td>
<td>10–18</td>
</tr>
</tbody>
</table>

*Participants acting as their own controls. GMFCS, Gross Motor Function Classification System; CP, cerebral palsy.*
After comparing the extracted data describing each study, the studies included in this systematic review varied in research design (i.e. heterogeneous studies). Therefore meta-analysis could not be done and findings are presented qualitatively.

Table 9 summarizes the outcomes of interest of these four studies and codes the outcomes of interest according to the different dimensions of disablement. All the outcomes of interest in these studies were at the level of impairment (Butler, 2003).

**Table (9): Summary of study results**

<table>
<thead>
<tr>
<th></th>
<th><strong>Fragala et al. (2003)</strong></th>
<th><strong>Lespargot et al. (1994)</strong></th>
<th><strong>Miedaner and Renander (1987)</strong></th>
<th><strong>McPherson et al. (1984)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intervention</strong></td>
<td>Manual stretch with hold for 40–60 seconds, 3 times for each movement, 1 or 2 times per week and routine positioning regime in classrooms</td>
<td>Manual stretch for 15–20 minutes in physiotherapy session and wedge-sitting 5–7 hours daily</td>
<td>Manual stretch with 5 repetitions for each joint hold for 20–60 seconds. One group having 5 days a week and one group having 2 days a week. After 5 weeks, the groups were switched for another 5 weeks</td>
<td>First year: manual stretch with hold for 60 seconds, 5 repetitions for each joint, 3 times a day and 5 days a week Second year: 30 minutes on prone-stander per day, 30 minutes on supine positioning device per day, 5 days a week</td>
</tr>
<tr>
<td><strong>Outcome of interest</strong></td>
<td>Passive range of hip flexion, hip extension, hip abduction, popliteal angle, knee flexion, and knee extension</td>
<td>Passive hip abduction angle</td>
<td>Passive range of movement of seven motions: hip flexion in the supine position with opposite leg free, hip extension in the prone position, hip abduction with hips and knees flexed, hip abduction with</td>
<td>Range of knee flexor contractures</td>
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</table>
hips neutral and knees extended, knee extension with hips flexed to 90°, (straight leg raising), ankle dorsiflexion with the knee extended, and forefoot inversion.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Goniometer</th>
<th>Specially designed apparatus</th>
<th>Goniometer</th>
<th>Goniometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension of disablement</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
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<tr>
<td>Results</td>
<td>No consistent changes in ROM across participants. No comparison of outcome of interest before and after stretches. Statistically decrease in PROM after the first non-stretch phase only.</td>
<td>Significant difference found only in right hip flexion and right straight-leg raising i.e. 2 out of 14 joint measurements after 5 days per week stretch. No significant difference between the 2 regimes of manual stretching except in right straight-leg raising i.e. 1 out of 14 joint measurements.</td>
<td>Knee extension increased an average of 4 to 10° during the treatment periods and decreased an average of 6 to 10° during the nontreatment periods.</td>
<td></td>
</tr>
<tr>
<td>Effect size (95% CI)</td>
<td>No raw data provided for calculation. Authors defined changes &gt;8° as real differences</td>
<td>Hip abduction with knee flexion, 6.13 (−6.31 to 18.56) and −1.38 (−5.02 to 2.27). Hip abduction with knee extension, 0.63 (−8.83 to 10.08) and -2 (−11.39 to 7.39)</td>
<td>Right hip flexion 12 (2.59 to 21.41) Right straight leg raising 8.2 (0.14 to 16.26)</td>
<td>Unable to calculate due to abnormal distribution of data.</td>
</tr>
</tbody>
</table>

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No raw data provided for calculation. Authors defined changes >8° as real differences.

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Right hip flexion 12 (2.59 to 21.41) Right straight leg raising 8.2 (0.14 to 16.26)

Error to calculate due to abnormal distribution of data.

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a The reliability and validity of the apparatus not mentioned in the text; b favours stretches; I, impairment; PROM, passive range of movements; CI, confidence interval.
There are four studies investigating the effect of manual stretching in improving the range of movement of identified joints (McPherson et al., 1984, Miedaner and Renander, 1987, Lespargot et al., 1994, Fragala et al., 2003).

One study showed no difference poststretching (Lespargot et al., 1994), but the other three studies showed some improvements in the range of movement.

The study by (McPherson et al., 1984) of level II evidence showed that there was a significant reduction in knee flexion contracture in three out of four treatment periods and a significant increase in knee flexion contracture in three out of four non-treatment periods. The difference in means between treatment and non-treatment phases were <10° in general. The effect size and 95% CI in this study were unable to be calculated due to the small sample size (four participants) and the violation of assumption of normal distribution of data.

The study by (Miedaner and Renander, 1987) of level I evidence showed a statistically significant increase in two out of 14 joint measurements after stretching five times a week for 5 weeks. The effect sizes of these two measurements were 8.2° and 12° respectively.

Although the level IV study by (Lespargot et al., 1994) did not use statistical comparison in range of movements before and after stretching, raw data of only four participants were available for the calculation of the effect size and the 95% CI. No statistical difference in the range of hip abduction was demonstrated after passive stretching.

The study by (Fragala et al., 2003) of level II evidence showed that children and youth with Severe Limitations in Self-Mobility may lose
PROM during nonintervention periods lasting greater than five weeks. No raw data was provided for the calculation of the effect sizes but the authors defined that changes greater than 8° were considered not due to measurement errors.
CHAPTER V
DISCUSSION

There is conflicting evidence on whether passive stretching alone can increase the range of movement in a joint. One study showed no difference poststretching (Lespargot et al., 1994), but three studies showed improvements in the range of movement (McPherson et al., 1984, Miedaner and Renander, 1987 and Fragala et al., 2003). For those studies showing improvements in the range of movements, the effect sizes were fairly small (in general less than 10°). All studies are of poor methodological quality (PEDro score of four or less) except one study of high quality (PEDro score of seven) which is (Miedaner and Renander, 1987).

As most of the authors in these studies did not declare their acceptable cut-off points for clinical significance, it is difficult to judge if those improvements in range of movements were clinically relevant (Herbert, 2000). Hence, there appears to be no conclusive evidence to definitely state that passive stretching can increase the range of movement in a joint, although there is some evidence favoring passive stretching in an increasing range of movements in children with CP.

The significant limiting factors of this systematic review are the existence of only a small number of studies, the small number of participants in each study and their heterogeneity, which has already been identified as a major barrier in research, particularly in children with CP (Stanley et al., 2000).

The children’s ages varied at the point of investigation, implying variability in their severity of tightness, chronicity, growth rate and their
stage of neuronal plasticity, which, in turn, affects the influence of different interventions.

The stretching techniques evaluated differed on the stretching time and number of repetitions, suggesting no standardization of stretching techniques. The tremendous variability in physical therapy practice across therapists, settings, and geographical regions indicates there is either a lack of evidence in the field or a failure to incorporate evidence. The balance is clearly shifting in recent years from the former to the latter, and our profession must now address how best to translate evidence into practice in a timely manner. Models of therapy delivery or exercise promotion are also evolving and we need to determine the role of direct therapies versus integrating exercise strategies and activity promotion within the context of everyday life (Damiano, 2009).

Passive stretching should only be used as an adjunct to other treatment techniques (e.g. heating), rather than solely on its own. In addition, clinicians should investigate ways of prolonging the effects of passive stretching by including it in the daily routine of patients. As there appears to be some evidence to show that sustained stretching is more effective than manual stretching of short duration in improving range of motion and reducing spasticity, perhaps emphasis should be placed on the optimum positioning of patients (both daytime and night-time positioning) so as to maximize the effects of passive stretching. Equipment such as orthoses, splinting, and serial casting can be used as alternatives to sustained stretching. However, this needs to be verified by studies of more rigorous methodological quality and of larger sample size.

Our understanding of the mechanisms of contractures in spastic muscles is rudimentary. Ideally our clinical decisions should be guided by
good scientific inquiry (Whyte and Hart, 2003). There is a need for laboratory research into the mechanisms of muscle contracture to provide additional information about the theoretical assumptions that guide physical therapy interventions for children with CP.

Clinical evaluation of the effects of stretching techniques is also needed because existing research evidence is not adequate to support or refute the effectiveness of stretching as a management strategy. Pediatric physical therapists have an essential role to play in this area of evaluation.

Therapists use stretching interventions for children with CP with the assumption that the stretching program will not only assist with maintenance of joint range of motion, but positively impact the functional abilities of the child. Many therapists also use stretching to avoid or delay the development of secondary complications. The current body of research on stretching does not include any investigation of the relationship between changes of joint range of motion and changes in functional abilities or need for surgery (Wiart et al., 2008).

According to World Health Organization (2001), The International Classification of Functioning, Disability and Health (ICF) explicitly cautions against assuming a direct relationship between factors at the component of body function and structure (e.g., range of motion, spasticity) and changes at the component of activity (e.g., dressing or riding a bike) and participation (e.g. integration in classroom activities).

For example, maintaining a child’s hamstring length may not make it any easier for him to get on and off the school bus (activity) or to participate in gym class at school (participation). A recent study evaluated the interrelationships among muscle tone, passive range of motion, selective motor control, and gross motor function in a group of children
with CP and reported only a modest relationship between motor impairments and participation in everyday activities (Ostensjo et al., 2004).

It is essential that future research includes the evaluation of the relationships among outcomes representing body functions and structures, activity and participation to determine both the physiological and functional outcomes of stretching programs, particularly because enhancing functional abilities is one of the reasons why therapists use stretching as a clinical intervention.

Another reason to consider alternative outcomes is the documented measurement error of goniometry with children with a diagnosis of CP. (McDowell et al., 2000) reported significant variability with measurements errors as high as 14° for 3 of the 6 range of motion measurements with 12 children with spastic diplegia. Other researchers have also reported significant measurement error using goniometry to measure joint range of motion with children with CP (Watkins et al., 1995).

Researchers need to consider more precise ways of measuring joint range of motion and the use of different outcome measures to document changes in children’s functioning.

Passive stretching is, by its very nature, a “passive” technique that is done without the child’s participation. Isolated active stretching and positioning practices such as prone lying and stretching hamstrings in long sitting are also not particularly fun for the child or family. Parents may be hesitant to use traditional stretching techniques as they may be uncomfortable for their children and they may already be overwhelmed by a number of other interventions their children require (Hadden and von Baeyer, 2002).
Contemporary approaches to rehabilitation for children with CP are changing to include community participation, fitness, and functional goals and therapists are challenged to explore innovative management approaches that reflect these values (Palisano et al., 2004). Perhaps the focus on maintaining joint range of motion needs to change to an emphasis on maintaining flexibility and encouraging the exploration and maintenance of a variety of movement options. All children, including children with physical disabilities, need to have opportunities to engage in physical activities that will enhance their levels of physical fitness. They also need opportunities to participate in fun activities with other children. From this perspective, the emphasis on joint range of motion changes to a focus on encouraging movement opportunities that enable children with CP to experience a repertoire of movement experiences and participate in enjoyable activities while enhancing their physical fitness.

Therapists may want to consider activities such as yoga, horseback riding (hippotherapy) and swimming programs that allow children to stretch and move within a functional, participatory context. Through such programs, children with CP could become active participants in fitness programs that encourage flexibility instead of passive recipients of therapeutic stretching routines. Therapists can use their expertise to identify innovative flexibility options that are enjoyable for everyone and will lead to lifelong fitness opportunities for the child (Campbell, 1997).

Physical therapists possess the knowledge of development, movement, and CP to assist children and adolescents with CP to participate in community fitness programs. Therapists can play an important role in the development of transitional programs in rehabilitation centers, in which typical fitness programs are adapted to meet individual movement abilities. Therapists can also help families to identify community programs and
provide support for the transition to these programs. Therapists can work with families and community fitness facilities to encourage children and adolescents with CP to integrate flexibility exercises into their regular fitness routines and to modify program content so that children and youth with motor disabilities can participate effectively and safely. It is an exciting time in pediatric rehabilitation and an ideal time for therapists to use their creativity, knowledge, and skills to develop innovative and fun strategies to integrate therapy with fun physical activities and to contribute to the rigorous evaluation of stretching strategies used in pediatric rehabilitation.
CHAPTER VI
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

This systematic review aimed to study the effect of manual stretching on muscle tightness in children with spastic cerebral palsy.

In order to answer this question we searched in PubMed, The Cochrane Library, PEDro and Google scholar using the words ("cerebral palsy", "stretching", "muscle spasticity", "contracture", "range of motion" and "physical therapy"). We expanded our search to all research designs except expert opinions dealing with spastic cerebral palsy from birth to eighteen years of age and used the manual stretching as a method of intervention. The outcome measure is passive joint range of motion.

According to the criteria mentioned we selected four studies for detailed descriptive analysis in order to critically appraise their results.
CONCLUSIONS

The current level of evidence to support the effectiveness of passive stretching in children with spastic CP remains weak. The main limitations are the inadequate rigorousness of the research designs and the small number of the participants involved. There are few conclusions that can be drawn from the existing evidence as follows: (1) there appears to be some evidence favoring passive stretching in increasing range of movements in children with CP, although the effect size remained small; and (2) there is some evidence to indicate that sustained stretching is preferable to manual stretching in improving range of movement and reducing spasticity in targeted joints and muscles in studies of children with spasticity.

At last we can conclude that it is evident that there is a significant gap between clinical rationale for stretching and research evidence.
RECOMMENDATIONS

1. It is recommended that physical therapists should have a positive attitude about evidence-based practice and to be interested in learning and improving the skills necessary to implement evidence-based practice.

2. Suggestions for future research include conducting appropriately powered well-designed randomized controlled trials regarding the effectiveness of passive stretching in spastic cerebral palsy with investigation of the optimal duration and frequency of stretching.

3. It is recommended to do further research using systematic reviews to study the effect of stretching exercises on different cases in pediatric physical therapy.

4. More research is needed in the following areas:
   - Mechanism of muscle contracture in spastic cerebral palsy.
   - Relationship between passive range of motion and functional outcome in spastic cerebral palsy.
   - Reliability of range of motion outcome measures.
   - Combination of stretching and other treatment modalities, such as; moist heat, massage, therapeutic ultrasound, electrical stimulation of opposite muscles group, strengthening exercises of antagonists and orthoses.
REFERENCES


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الملخص العربي

عنوان البحث:
فحص منهجي لتأثير الطالة اليدوية على قصر العضلات في الأطفال المصابين بالشلل الدماغي التقلسي.

الهدف من البحث:
الهدف من هذه المراجعة منهجية تقييم فعالية دراسات تمارين الإطالة اليدوية وتأثيرها على قصر العضلات في الأطفال المصابين بالشلل الدماغي التقلسي.

أسلوب البحث:
استخدام الدراسات التي تضمنت تجارب عملية لتمرينهات الإطالة اليدوية في حالات الشلل الدماغي التقلسي بمراكز المعلومات والبحث العلمي PEDro وbiblioteca Cochrane وكتاب Pubmed وتمت مراجعة العناوين والملخصات لاختيار المقالات المتعلقة بالموضوع.

النتائج:
تضمنت هذه الدراسة:
أربع تجارب عملية، أظهرت النتائج أن المستوى الحالي للدليل لدعم فعالية الإطالة اليدوية في الأطفال المصابين بالشلل الدماغي التقلسي يبقى ضعيفاً.

النصحات:
1- نشر الوعي بالأخصائي العلاج الطبيعي بأهمية الممارسة العملية المنوية على الدليل في مجال العلاج الطبيعي للأطفال.
2- يجب عمل التجارب العشوائية المحكمة جيدة التصميم في المستقبل لبحث تأثير الإطالة اليدوية على قصر العضلات في الأطفال المصابين بالشلل الدماغي التقلسي.
3- عمل المزيد من الأبحاث العلمية في النقاط الآتية:
   0
العلاقة بين المدى الحركي للمفاصل والنتيجة الوظيفية في حالات الشلل الدماغي

- مصداقة قياسات المدى الحركي للمفاصل.
- ال]={مع بين تمارين الإطالة اليدوية والوسائل العلاجية المختلفة، مثل الحرارة والتدليك والموجات فوق الصوتية العلاجية والتنبيه الكهربائي للعضلات وتمارين التقوية والجبائر.
تأثير الإطالة البدوية على قصر العضلات في الأطفال المصابين بالشلل الدماغي التقلصي
(فحص منهجي) / أحمد محمد السيد النحاس؛ تحت إشراف: إ. إ. إ. خ. النحاس، استاذ
مفتوع بقسم العلاج الطبيعي لاضطرابات مراحل النمو والتطور وجرحتها عند الأطفال،
كلية العلاج الطبيعي - جامعة القاهرة؛ د. محمد بدر إبراهيم، مدرس بقسم العلاج الطبيعي
لاضطرابات مراحل النمو والتطور وجرحتها عند الأطفال، كلية العلاج الطبيعي - جامعة
القاهرة؛ رسالة ماجستير، 2011.

المستخلص

الهدف: تهدف هذه الدراسة إلى فحص منهجي لتقهيم فعالية دراسات تمارين الإطالة البدوية
وتؤثرها على قصر العضلات في الأطفال المصابين بالشلل الدماغي التقلصي، طرق البحث:
فحص منهجي لجميع التجارب المتاحة بجميع تصميمات البحث العلمي ماعدا أراء الخبراء
واشتملت الدراسات على الأطفال الذين يعانون من الشلل الدماغي التقلصي وترابح Cochrane
أعمارهم منذ الولادة حتى ثمانية عشر عاما وتم البحث في Google وبحث العلمي
حتى شهر سبتمبر عام 2010 وقد تم تقييم المدى
الحركي السلبي للمفاصل. نتائج الدراسات: أربعة دراسات فقط وافقت المعايير السابقة
وسبب التباين الواضح بين هذه الدراسات، لم يمكن عمل تحليل إحصائي مشترك وتم
الاكتفاء بالشرح. هناك أدلة متعارضة على زيادة المدى الحركي السلبي بواسطة الإطالة
البدوية. دراسة واحدة أظهرت عدم وجود اختلاف في المدى الحركي بعد الإطالة البدوية،
بينما أظهرت الثلاث دراسات الأخرى وجود تحسن في المدى الحركي للمفاصل ولكن
بحجوم تأثير صغيرة جدا (عُمومًا أقل من 0٪). كل الدراسات كانت قليلة الجودة ما عدا
دراسة واحدة فقط عالية الجودة. الاستنتاج: المستوى الحالي للدليل لدعم فعالية الإطالة
البدوية في الأطفال المصابين بالشلل الدماغي التقلصي يبقى ضعيفًا.

الكلمات الدالة: فحص منهجي، الشلل الدماغي، تمارين الإطالة، المدى الحركي والشلل
التشنجي.
تأثير الإطالة اليدوية على قصر العضلات في الأطفال المصابين بالشلل الدماغي التقلصي (فحص منهجي)

توطنة
لحصول على درجة الماجستير في العلاج الطبيعي

مقدمة من
أحمد محمد السيد النحاس
بكالوريوس العلاج الطبيعي
قسم العلاج الطبيعي لاضطرابات مراحل النمو والتطور وجراحتها عند الأطفال

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جامعة القاهرة

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