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The effectiveness and efficacy of stretching and proprioceptive neuromuscular facilitation on the context in spastic diplegic cerebral palsy children

Abstract

Introduction: Spasticity is a upper motor neuron disorder and can be seen in neurological conditions like and stroke and multiple sclerosis. Although the incidence rate of spasticity is unknown, it can put pressure on the health conditions of those with spasticity, and there is no absolute effective way to control it. Cerebral palsy is a common problem, worldwide incidence being 2 – 2.5 /1000 live birth. As much as 75-80%of the cases are due to prenatal injury with less than 10% due to significant birth trauma or asphyxia. The most important risk factors seem to be prematurity and low birth weight.

Background: Proprioceptive neuromuscular facilitation stretching techniques are commonly used in the athletic and clinical environment to enhance and both active and passive Range of Motion (ROM) with a view optimizing motor performance and rehabilitation. PNF stretching is positioned in the literature as the most effective stretching techniques when the aim is to increase ROM, particularly in respect of short-term ranges

Objective: To find out the effectiveness of the PNF technique for the tightness of lower limb muscles in spastic diplegic CP. To find out the effectiveness of stretching for the tightness of the lower limb muscles in spastic diplegic CP. Hence, to compare the effectiveness of PNG versus stretching for the tightness of lower limb muscles in spastic diplegic CP.

Method: PNF technique was conducted to aid the rehahibilation of clients with spasticity and paresis by either facilitation or muscle elongation, supposedly through enhanced inhibitory mechanism affecting the target muscle and or improving muscle strength through excitatory mechanism affecting the target muscles. Maximal resistance has been considered to be the most important means of stimulation the proprioceptors s and the techniques concerned with its application to the patterns of mass movements are basic.

Results: This article is concerned with proprioceptive neuromuscular facilitation stretching techniques that aim to elongate a muscle, it really emphasis the patients who belong to group receiving stretching showed slower improvement than the PNF for a given period of time. The time or early regaining of functional independence is very much useful during the management of spasticity patients.

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Keywords: Spasticity; Cerebral palsy; Sarcomeres; Spastic diplegic CP.

Abbreviations: MS: Multiple Sclerosis; MTU: Muscle Tendon Unit; ROM: Range of Motion; CP: Cerebral Palsy; TMS: Transcranial Magnetc Stimulation; BoNT-A: Botulinum Neurotoxin-A; TD children: Typically Developing Children.

Conclusion and discussion: The study concluded and emphasis the propriceptive neuromuscular facilitation is more valid for the recovery of functional activities in the patient's following spasticity than the stretching. On the other hand, the two techniques are significant. It really emphasis that the patients who belong to group receiving stretching showed slower improvement than the PNF for a given period of time.

Evidence based treatment approach: Any approach which is evidence based might be more attractive in the society. There by the stretching also belongs to the best among the evidence-based treatment.

Introduction

Cerebral Palsy- it is an umbrella term covering a group of non-progressive, but often changing, motor impairments syndrome secondary to lesion or anomalies of the brain arising in the early stages of its development. Tightness in one or more Muscle Group (MG) affects 70-80% of individual with CP. Hamstring tightness is most common of all. Now, significant effects were observed when the popliteal angle exceeds 85° ($p<0.001$) and included increased effort of walking, decreased speed, stride and step length, decreased hip flexion and increased knee flexion instance, increased posterior pelvic tilt, decreased pelvic obliquity and rotation , and premature ankle dorsi-and plantar- flexion instance.

The article is concerned with Proprioceptive Neuromuscular Facilitation (PNF) stretching techniques that aim to elongate a muscle. Now, the muscle or muscle group to be stretched will be referred to as the 'target muscle(s)' while a muscle or muscle group on the opposite side of the segment or joint will be termed the 'Opposing Muscle(s)' (OM) [1].

Cerebral palsy is a non-progressive disorder caused by a brain lesion taking place in the ealy stages of development [2]. The neurological lesion in CP causes adaptations in the muscle, including muscle atrophy [3], fibrosis [4], muscle shortening [5] and overstretched sarcomeres [6]. The combination of longer sarcomeres with shorter muscle fibers means that there will be fewer in-series sarcomeres [6]. Henceforth, there is a lack of muscle growth [7,8]. This dynamic shortening of the muscles is typically treated with stretching exercises, botulinum toxin injections, casting or ankle-foot-orthoses. Eventually, if these treatments are not sufficiently effective fixed contractures can develop, which is treated with surgery.

One of the main aims of the present study which try to maintain or increase ROM is to improve the gait pattern. On the other hand, increase in Muscle-Tendon Unit (MTU) length could be gained by permanently stretching existing structures, this is probably less desired as a carry- over effect to function may not occur. To improve functionality, the increase in length should be rather achieved by building new contractile materials in-series within the MTU. Ideally, we want to promote large, strong, and flexible muscles that allow contractile function across muscle's full range of motion. Therefore, interventions should aim to increase fibers length by promoting serial sarcomerogenesis. According to force-length characteristics of muscle [9].

Stretching, mechanism and effect – *Efficacy of stretching*

Stretching aims primarily to augment the viscoelastic components of the Muscle Tendon Unit (MTU), in an attempt to decrease it likelihood of sustaining muscle tendon injuries. Long-term long-force stretching introduces plastic deformation in connective tissue, an effect that is amplified when the connective tissue is heated before stretching and cooled after stretching ceases. Enhancing ROM is the main objective of stretching, but there are additional alterations to functional parameters such as maximal isometric torque, muscle-tendon stiffness, Passive Resistive Torque (PRT), and structural parameters, including muscle and tendon stiffness, fascicle length and pennation angle that can occur after stretching [10-13].

In the context of chronic stretching, two plausible explanations can impact the MTU. First, the sensory theory, suggests that the tolerance to stretch could potentially increase, implying increased passive tension after intervention, with no alteration in tension for a given length. Second, mechanical theory, indicates a reduction in joint resistance, such as decrease in passive joint torque at a particular angle, possibly as a result of the mechanical properties or geometry of the MTU [14].

Muscle and tendon properties in CP patient

The mechanical properties of a muscle dictate the degree of its length alteration in response to an applied force. This response depends partly on the geometry of the muscle, as well as on the intrinsic tissue material properties. In this paper we will discuss the changes that occur to the architecture and the mechanical properties of the medial gastrocnemius muscle in children with CP.

To do this, it is common to use a simplified pennate muscle model of the medial gastrocnemius. Now, in this model the MTU consists of a muscle and a tendon placed in series, where the changes in the muscle belly length are dependent on changes of the muscle fascicles and the pennation-angle. The medial gastrocnemius is most commonly studied in children with CP for a few reasons- it is a superficial muscle, therefore suitable for most imaging techniques and this muscle is essential for functional tasks such as walking.

On the other hand, the architectural structure of muscles can be studied in a straightforward manner with medical imaging techniques such as MRI [15] and 2D, [16] or 3D ultrasound, [17,18], while the mechanical properties (i.e stiffness) of a muscle can be assessed by applying a known tensile force to the tissue and measuring the resultant elongation [19]. Heneforth, due to anatomical constraint, some assumptions need to be made when quantifying *in vivo* muscle and tendon stiffness. For example, while applying a passive moment around the ankle joint to dorsiflex the foot, the lengthening of the medial gastrocnemius MTU achieved depend s on the MTU's moment arm length [20], the properties of all agonist plantarflexor and antagonist dorsiflexor MTUs acting around the ankle joint, and the properties of all passive structures within the joint (i.e ligaments and joint capsule). These factors might vary with ankle joint, making it difficult to quantify the passive force carried by MTU during passive joint rotation. Alternatively, instead of calculating muscle stiffness in absolute terms, we can estimate the relative contribution of muscle and tendon to the joint's ROM as the muscle and its tendon are placed in series and therefore the passive force along these two structures is expected to be the same.

Muscle arhitecture in CP

There is consistence evidence that the medial gastrocnemius muscle in children with spastic diplegia in CP is shorter in paretic leg of children with CP compared to matched typically developing children [5,21,22]. This is accompanied by greater a length of the Achilles tendon in children with CP [23,24]. Moreover, some recent studies reported reduced muscle fascicle lengths at rest in children with CP than in TD (typically development) children [25-29], but others have not detected differences [16,22].

These findings can have significant functional consequences. Shorter muscle fascicles with fewer sarcomeres in series, as found in children with CP [6,30,31], will have a limited potential for active shortening. Hence, this would in turn influence the force generating capacity of the muscle [32]. Moreover, it has also been shown that the force-length relation of muscles in children with CP with different to that of Typically Developing (TD) children, with maximal torque generation occurring at a more plantar flexed position [29]. This may be a contributing factor to gait impairments such a toe-walking, the more plantarflexed joint position during gait would take advantage of the altered moment-angle relationship. Now, these findings highlights that it is essential to increase fibers length and extensibility to improve the force-length relation of the muscle, firstly with respect to the position at which maximal torque is produced and secondly with respect to the range over which force can be produced [33].

The effect of stretching on muscle and tendon properties in children with CP

Muscle stretching, in the form of passive stretching exercises, orthotics, casting, standing tables, of a combination of these modalities, has been recommended in the early management of joint hyper-resistance in children with CP [34-37]. Moreover, here we assess the effect of traditional - stretching exercises on muscle and tendon properties. Henceforth, there is an abundance of literature showing a positive effect of stretching exercises on ROM [38], functional indexes such as gait parameters, walking velocity and gross motor function rarely improve [39].

Improving the effectiveness of stretching in CP

Now, as discussed above, stand-alone stretching methods applied manually, with AFO's or serial casting do not seem effectively improve the muscle and tendon. Adaptations seem to be either absent or in a negative direction after a period of stretching. Moreover, in this context, a combination of treatments has been tried to increase the stretch-stimulus to the muscle.

Botulinum toxin A- and stretching

Botulinum –A is a common in clinical practice is the combination of intramuscular Botulinum neurotoxin –A (BoNT-A) injections with stretching by serial casting. The hypothesis is that BoNT-A injections temporarily reduce the symptoms of excessive tonic discharge thus providing a *window of opportunity* during which adjunctive interventions such as serial casting and physiotherapy can be implemented to improve, or at least prevent further deterioration of, muscle –structure and functionality [40].

Specific collagenase enzymes and stretching

To avoid the negative effects of BoNT-A injections on the muscles, another way to reduce the stiffness of spastic muscle has recently be proposed. But it was hypothesized that injecting specific collagenase enzymes, to digest part of the extensive collagen in the extracellular matrix [41], which plays a vital role in contractures would reduce muscle stiffness [42].

Moreover, this theory is about to tested in a spastic mouse model, but it is hypothesized that if selective collagenase is injected in spastic muscle at an appropriate dilution and concentration in combination with a stretching program, it might lead to increase ROM and improvements in sarcomere lemgth, hence enhancing force production over the newly acquired ROM [42].

Conclusion

Stretching interventions may be beneficial to prevent worsening of muscle contractures [43], and hence an isolated treatment, they do not promote muscle-length growth or improve function in children with CP.

Declarations

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Compliance with ethics requirements: The authors declare no conflict of interest regarding this article. Informed consent was obtained from all the concerned patients included in the study.

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