Acta Scientific Orthopaedics (ISSN: 2581-8635)

Volume 4 Issue 6 June 2021

Research Article

Cyclic 1 Minute Versus 20 Minutes Hamstrings Stretch for Spastic Cerebral Palsy

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Received: April 30, 2021

Published: May 28, 2021

Abstract

Background: Children with cerebral palsy suffer from a wide range of complications which may be neurological, muscular or skeletal. Muscle tightness is a common musculoskeletal complication in cerebral palsy. Stretching exercises are one of the used methods to decrease muscle tightness but there is a lack of agreement on the effective time of single stretching session.

Objectives: To compare between 1-minute and 20-minutes stretching of hamstring.

Patients and Methods: This study was conducted on 20 children with diplegic cerebral palsy classified into 2 equal groups (group A and B). The cyclic 1-minute stretch was applied for group A and 20-minutes positional stretch was applied for group B. Their age ranged from 7 to 10 years, their degree of spasticity ranged from 1 to 2 according to modified Ashworth scale with degree of popliteal angle ranged from 30 to 45 degrees and level II or III according to gross motor function classification system. Nexus 10 by (Mind Media) was used as Surface electromyography device to monitor hamstring activity. Popliteal angle was measured by Digital inclinometer.

Result: Motor unit amplitude during stretch of group A increased significantly more than motor unit amplitude of group B ($p < 0.001$). No difference between motor unit amplitude of group A and motor unit amplitude of group B post stretch ($p > 0.05$).

Conclusion: The stretching exercise for hamstrings in children with diplegia has no significant effect on decreasing motor unit amplitude and muscle tension after one session of stretching. If we used stretching exercises on daily basis as a method of controlling hamstrings tightness, it is better to use the 20-minutes positional stretch than the cyclic 1-minute stretch.

Keywords: Stretch Time; Hamstrings Stretch; Spasticity; Cerebral Palsy

Introduction

Cerebral Palsy (CP) can be defined as heterogonous permanent upset caused by non-progressive harm to the developing brain. During this disorder, injury or malformation happens within the growing nervous system before, during, or shortly after birth [1]. Even though the course of the primary lesion, anomaly or injury is stationary [2], the appearance of neuropathological lesion and the clinical signs may be different with time as the central nervous system matures [3].

Cerebral palsy is the main cause of physical disability in childhood, with reported prevalence rates in the range of I.5 to 3.6 per 1000 children [4-7].

Cerebral Palsy is considered an upper motor neuron lesion with positive and negative signs. Positive signs embrace hypertonia, dyskinesia, hyperreflexia, released primitive reflexes, and secondary associated musculoskeletal problems. Negative signs include improper postural control mechanism resulting in muscle weakness, decreased coordination, decreased balance and gait deviations [8].

Diplegia as one of the topographical types of cerebral palsy, appears in infancy or early childhood, and results in improper muscle control and coordination. Affected people have hypertonia in both upper limbs and both lower limbs but upper limbs are less affected than lower limbs [9].

It is commonly due to perinatal hypoxic-ischemic insult causing lesions in the white matter adjacent to the lateral ventricles of the brain, or periventricular leukomalacia (PVL).

In cerebral palsy the passive muscle extensibility diminishes with age, this gradual loss of extensibility is the clinical sign of a real histologic muscle changes with myofascial thickening, this muscle changes may be more prominent than spasticity. Once hamstrings are too tight, they will resist forward pelvic movement, at the same time with forward trunk flexion to neutral [10].

There is disagreement on the optimum duration of a single stretch cycle and the number of cycles that should be applied in a daily basis to achieve the greatest benefits from stretch to reduce muscle tightness and improve range of motion. Several terms are used to describe long-duration stretch as sustained, prolonged, maintained and static. Other terms are used to describe short-duration stretch as intermittent, ballistic or cyclic. All these terms including long and short duration are time frameless [11].

Stretch reflex is a contraction of muscle due to stretching of muscle spindle. Its function is to regulate skeletal muscle length. When a muscle stretched, the muscle spindle is lengthened and nerve firing increases. Alpha motor neuron activity increases as a result of this firing from afferent fibers of the supplying nerve, causing extrafusal muscle fiber contraction (increases motor unite output) and this contraction resists the act of stretch [12].

The Golgi tendon organ (GTO) counteract the effect of stretch reflex (inverse myotatic reflex). It protects the muscle from over tension because it inhibits the excitatory stimuli from alpha motor neurons. So, it has a vital role during stretching exercises as it helps the muscle to relax during time of stretching to avoid injury [12].

Over time during stretch the firing of the tendon organ continues to overcome the firing of alpha motor neuron resulting in a state of muscle relaxation. So, the unfavorable sensation due to tension of muscle during stretch decreases after a period of time due to Golgi tendon organ induced relaxation.

It is better to sustain passive stretching exercise for a proper period of time to give the chance for GTO to inhibit the discharge of alpha motor neuron, the proper time can be estimated from monitoring motor unit output as a result of stretching.

In this study the electromyography was used to compare the motor unite amplitude of hamstrings pre, during and post stretch of the stated methods of stretch.

Methods

Participants

This study was administered over a period of 8 months from July 2020 to February 2021. Children were selected from the pediatrics habilitation unit of the outpatient clinic of faculty of physical therapy, Cairo University. Twenty children of both sexes (9 boys and 11 girls) with spastic diplegia met eligibility criteria, their age ranged from 7 to 10 years old, able to follow instructions, with Degree of spasticity 1 to 2 according to modified Ashworth scale [13]. They can walk alone with limitation or walk with walking aids (grade II and III) according to gross motor function classification system scale (GMFCS) [14]. They have a passively full extended knee in supine position, they have a popliteal angle of 30 to 45 degrees. And excluded if they have Bone deformities in lower limb, epilepsy, urinary or fecal problems and if injected with botulinum toxin or undergone surgery in hamstrings within the 12 months prior to taking part in the study.

Ethical approval: The study was approved by research ethics committee faculty of physical therapy Cairo university and an informed written consent was taken from each participant in the study.

Materials and procedure

Testing of popliteal angle

By the use of digital inclinometer; the inclinometer was held in a horizontal position before measurements, the angle was measured in a supine lying position with the hip flexed to a position in which the femur is vertical on the plinth (90 degrees of hip flexion). The inclinometer was placed below the tibial tuberosity and the lower leg was straightened to the available knee extension ROM to measure the angle. Three times of measurements were done and the mean value was used in the analysis.

Testing of popliteal angle as a method of assessment for muscle tightness was used to select the subjects who met criteria (30 to 45 degrees of popliteal angle) to ensure that all subjects have almost the same degree of hamstings tightness before enrollment to the study.

Monitoring of hamstring muscle activity

Surface EMG was used to monitor hamstring activity before, during and after stretching, Nexus 10 by (Mind Media B.V.) was used as SEMG device. Nexus-10 is a biofeedback and physiological monitoring platform that uses flash memory and Bluetooth 1.1 class 2 communication technologies. Nexus-10 allows for gathering of data at up to 2048 samples/second. Nexus-10 can be used for recording of different physiological signals including EMG, ECG, EEG, EOG, true DC and slow cortical potentials. Noise levels are very low by this design Because Nexus-10 uses cables of carbon with active shielding.

Nexus 10 is considered valid and reliable research tool for assessment of skeletal muscle activation [15].

The 20 children were divided into 2 groups and only one session for each group was performed:

1. **Group (A):** The stretching in this group was formed of five repetitions and the time of stretch for each repetition was one minute with 1-minute rest between each repetition.
2. **Group (B):** The stretching in this group was formed of one repetition and 20 minutes stretching time.

Recording from the muscle

The skin on the posterior aspect of thigh was cleaned by alcohol. The child was in supine position on a plinth inside the universal cage unite (spider cage) and his waist was supported by a belt to prevent pelvic movements during stretch. The recording electrodes of nexus 10 was positioned on muscle belly and the common reference electrode was positioned on a bony prominent site. The software program of nexus 10 was adjusted on EMG recording. Knee splint was applied on both lower limbs to prevent the child from flexing his leg during the procedure. The untested limb was also fixed in neutral hip position by belt. The muscle activity was recorded at resting state for 5 minutes. The leg then was raised till the hip reached 70 degrees of flexion which measured by inclinometer (this range was adequate and comfortable for stretching in both study groups) the hip flexion angle was maintained by V-shaped tight rope that was fixed at universal cage unite, the rope also was attached to the child leg at the lower third of leg. Recording from the muscle will be at all time of stretch. During stretch the tracing of muscle activity will be monitored on the personal computer screen. For group A, the session was formed of 5 minutes recording before stretch, 10 minutes recording of stretch relaxation cycle (1 min stretch followed by 1 min relaxation for 5 repetitions) and 5 minutes recording post stretch. For group B the session was formed of (5 minutes recording pre stretch, 20-minutes continuous positional stretch and also, 5 minutes recording post stretch). During all time of stretch the child under investigation was kept calm by playing also any artifact during recording was excluded from evaluation. We use a stop watch and the software of Nexus 10 to accurately control the time.

Data analysis

Comparison of age and popliteal angle between groups was done by Unpaired t test. Comparison of spasticity degree and sex between study groups was done by Chi-squared test. Comparison of the median values of GMFCS between the 2 groups was done by Mann-Whitney test. Subsequent multiple comparison was done by Post-hoc tests using the Bonferroni correction. Unpaired t test was conducted to compare motor unit amplitude between groups. $p < 0.05$ was set as level of significance for all statistical tests. All statistical analysis was carried out via statistical package for social studies (SPSS) version 22 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics

Table 1 shows the subject characteristics of the group A and B. No significance between study groups in age, popliteal angle and GMFCS ($p > 0.05$) was found. No significance also, in sex and spasticity grades distribution between study groups ($p > 0.05$) was found.

	Group A	Group B	p-value
Age, mean ± (SD), years	8.3 ± 1.25	8.6 ± 1.17	0.58
Popliteal angle (degrees)	35.4 ± 2.83	36.3 ± 4.02	0.57
GMFCS, median	2	2	0.64
Sex, n (%)			
Girls	6 (60%)	5 (50%)	0.65
Boys	4 (40%)	5 (50%)	
Spasticity grades, n (%)			
Grade I+	8 (80%)	7 (70%)	0.6
Grade II	2 (20%)	3 (30%)	

Table 1: Basic characteristics of participants.
SD: Standard Deviation; p-value, level of significance.

Effect of stretch time on motor unit amplitude

Comparison within group

Within-group comparison revealed a significant increase in motor unit amplitude of group A during stretch compared with that pre stretch (p < 0.001) and post stretch (p < 0.001) and non-significant difference between pre and post stretch (p > 0.05). There was no significant difference in motor unit amplitude between pre, during and post stretch in group B (p < 0.001) (Table 2).

Comparison between groups

There was no significant difference in motor unit amplitude pre-treatment between groups (p > 0.05). While the motor unit amplitude of group A had a significant increase when compared with that of group B during stretch (p < 0.001). There was no significant difference in motor unit amplitude between group A and B post stretch (p > 0.05) (Table 3).

Motor unit amplitude (mV)	Pre stretch	During stretch	Post stretch	p-value		
	Mean ± SD	Mean ± SD	Mean ± SD	Pre vs during	Pre vs post	During vs post
Group A	2.82 ± 2.01	11 ± 2.8	2.93 ± 1.46	0.001	1	0.001
Group B	2.62 ± 0.91	2.41 ± 0.63	2.26 ± 1.37	1	0.65	1

Table 2: Comparison mean value of motor unit amplitude pre, during and post stretch of group A and B.
SD: Standard Deviation; p-value, Level of significance.

Motor unit amplitude (mV)	Pre stretch	During stretch	Post stretch
	Mean ± SD	Mean ± SD	Mean ± SD
Group A	2.82 ± 2.01	11 ± 2.8	2.93 ± 1.46
Group B	2.62 ± 0.91	2.41 ± 0.63	2.26 ± 1.37
MD	0.2	8.59	0.67
t- value	0.28	9.42	1.04
	p = 0.77	p = 0.001	p = 0.3

Table 3: Comparison mean value of motor unit amplitude pre, during and post stretch of group A and B.
SD: Standard Deviation; MD: Mean Difference; p-value, Level of significance.

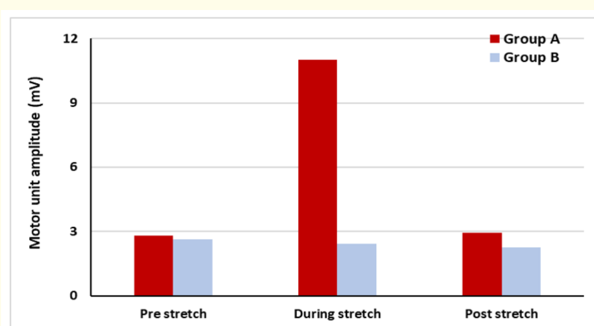

Figure 1: Motor unit amplitude pre, during and post stretch of group A and B.

Discussions

The current study was designed to compare the effects of 2 different stretch times in Egyptian cerebral palsy children aiming to create a clear and precise understanding of controlling hamstrings tightness. We used the motor unit amplitude which reflects the state of muscle tension as a guide to identify the effect of stretch on muscle tension and to determine the proper time of stretching needed to make this tension decreases. Nexus-10 as a device of surface EMG was used to monitor the motor unit amplitude of hamstrings pre, during and post stretch which inferred us about the state of muscle tension. So, by comparison between groups we identified the effect of each method of stretching and which of them has the appropriate time. The results of this study have multiple aspects, one of them clarifies the relation of pre-stretching (resting) motor unit amplitude between the study groups, another one clarifies the relation between pre, during and post stretch motor unit amplitude within each group. And finally this one that clarifies the relation of during and post stretch motor unit amplitude between study groups.

In this study we find that there is no significant difference between the values of pre-stretch mean motor unit amplitude which indicates the consistency between groups, hence excluding the individual differences of resting motor unit amplitude that may affect the results.

By comparison within groups we find that there is no difference between pre, during and post stretch motor unit amplitude for group B. For group A we find that there is no significant difference between pre and post stretch motor unit amplitude but there was significant increase in motor unit amplitude during stretch when compared with pre-stretch status which indicated that muscle tension was increased during stretch with the use of cyclic 1-minute stretch. By comparison between groups we find that there is no significant difference in post stretch motor unit amplitude between the two groups and there is significant increase in during stretch motor unit amplitude of group A when compared with that of group B.

From these results we concluded that the stretching exercise for hamstrings in children with diplegia is not effective method for decreasing motor unit amplitude and muscle tension after one shot of stretching. If we used stretching exercises on daily basis as a method of controlling hamstrings tightness, it is better to use the 20-minute positional stretch than the cyclic 1-minute stretch, as the muscle during 20-minutes stretch was more relaxed than that during cyclic 1-minute stretch in which the firing of the muscle was more markedly increased relative to the pre-stretch status and to that of 20-minutes. This relaxation during period of stretch may have a significant effect on decreasing post stretch motor unit amplitude and tension which indicates post stretch relaxation when the stretch applied on daily basis program.

Physical therapy is important for spasticity treatment in children with cerebral palsy. Some authors [16-18] concluded that stretching increases joint motion range via spasticity modulation and increase of soft tissues flexibility, other investigators [19-21] advocate that stretching had no significant effect on decreasing spasticity.

In a systematic review study conducted to evaluate the effect of passive stretching in children with spastic cerebral palsy (CP). The included studies evaluated stretching in which the joint is held by mechanical method (generally for thirty minutes at a time) and manual stretching with the joint held generally for up to sixty seconds (up to twenty minutes in 1 study); some studies used both kinds of stretching. The study assessed changes in spasticity, range of motion and gait. In this study there was limited evidence that stretching can decrease spasticity, improve joint range of motion and improve gait in children with cerebral palsy [22].

In another systematic review study which aimed to investigate the effect of stretch on muscle contracture in subjects with or at risk of contracture developing. measurements were done for mobility of joint, pain degree, limitations of activity, quality of life, restrictions of participation, spasticity and adverse events. 49 study was selected but no one applied stretching exercises for more than 7 months. The results showed that stretch didn't have important effect on mobility of joint in subjects with or without neurological problems if applied for less than 7 months [23].

Tibialis anterior and calf muscles activity during walking cycle was investigated pre and post thirty minutes of standing on a tilt-table with the ankle joint in dorsiflexion to stretch the calf muscle in the study group or after a period of rest in the control group. Calf and tibialis anterior electromyography signals were recorded concomitantly with footswitch signals by a computer. Videos were made for walking movements in sagittal plane. Passive muscle stretch effects were determined by comparison of change scores for selected muscle activation and spatiotemporal parameters between the groups. The investigator concluded that passive muscle stretching has no significant effect on spatiotemporal parameters and on the parameters of the calf and tibialis anterior activation [19].

In a study designed to compare between the effect of isotonic stretch with and without weight bearing (W.B) and isokinetic stretch on ankle planter flexors spasticity. patients received a 20-min single session of isotonic (with or without W.B) or isokinetic stretch. Measuring the Hoffmann reflex (H-reflex) latency and the amplitude ratio of the maximum H-reflex to that of the maximum motor action potential of the soleus muscle were used to evaluate the excitability of alpha motor neurons. The study concluded that there is no significant effect of those three treatments (isotonic with W.B - isotonic without W.B - isokinetic stretch) on calf spasticity. However, the lack of a demonstrable treatment benefit may be due the use of a single, instead of repeated cycles of stretching [21].

In a randomized controlled trial conducted to examine stretching effects on stroke patients. forty adults with stroke or stroke-like brain injury received thirty minutes stretch of the wrist and finger flexors 5 days a week for 4 weeks. The primary outcome was contracture. Secondary outcomes were upper-limb activity and pain at rest. The study concluded that 4 weeks of stretching has no significant effect on wrist joint contracture, pain or upper-limb activity [24].

In a study conducted on 16 children with diplegia to investigate the short-term effects of positional stretch on degree of spasticity by using the Modified Ashworth Scale, H/M ratios, H responses and goniometric passive joint motion range measurement. after application of positional stretch for 20 minutes, gastrocnemius muscle hypertonia decreased significantly [25].

In a previous study in which quantitative determination of the effects on muscle tone by stretch and loading was made in 9 paraplegic patients. Muscle tone was measured pre and post thirty minutes of stretching or weight bearing in 8 sessions on four days. Stretch was done by using orthosis to make the foot in ankle dorsiflexion with patient in supine. For weight load on the lower limbs, the patient stood on a tilt-table at an angle of 85 degrees with feet in 15 degrees dorsal or plantar flexion. The procedures tested all resulted in reduction of muscle tone and the passive ankle dorsiflexion resistance decreased significantly [26]. In the same year Odeen find that mechanical stretching of the hip adductor in cerebral palsy children causes increase in hip abduction joint motion range and decrease in myoelectric activity of hip adductor during active hip abduction [17].

In a study conducted to investigate the short term effects of a single session of prolonged muscle stretch (PMS) on reflex and voluntary muscle activations in children with spastic cerebral palsy. children received passive calf muscle stretch by standing on a modified tilt table for 30 minutes, in this study the passive ankle dorsiflexion range increased and the neuromuscular responses (torque and EMG activity) to the ankle joint passive and active movement were also reduced significantly [18]. Another previous study showed that stretching of calf muscle via "standing" in a frame for 45 minutes twice daily for 6 months did not change the latency and amplitude of the H-reflex [20]. However, the treatment time of this study was longer than that of other studies [17,18,26].

In a study conducted to investigate the efficacy of manual hamstring stretching in 11 children with spastic cerebral palsy. For each subject, one leg was randomly assigned to receive stretch and the other leg used as a control. Hamstring flexibility was tested on both legs pre and post stretch, using a Biodex dynamometer. stretching was provided by a physical therapist assistant 5 days per week for 8 weeks, including 5 repetitions of a 60 second. This study suggests that manual hamstring stretching can improve range of motion and may impede contracture progression [27].

In a study conducted to investigate the effects of static stretch on calf muscle. As a result of stretching the passive ankle dorsiflexion range increased, resulted in progressive decrease of the H-reflex. The study suggest that passive muscle stretch can decrease spasticity and improve the antagonist muscle function. But the effective time of a single passive muscle stretch has not been studied [16].

In a study designed to assess the effect of acute passive stretching on calf muscle in cerebral palsy. Children received stretch for 20 seconds and 5 repetitions. All variables were significantly greater during pre-and post-stretch trials compared to resting angle and were independent of stretch technique [28].

Limitation

A small number of cerebral palsy children participated in the study.

Recommendation

Additional research is recommended to determine the effect of daily 20 minutes of positional stretch on hamstring muscle for children with diplegia.

Conclusion

The stretching exercise for hamstrings in children with diplegia has no significant effect on decreasing motor unit amplitude and muscle tension after one session of stretching. If we used stretching exercises on daily basis as a method of controlling hamstrings tightness, it is better to use the 20-minutes positional stretch than the cyclic 1-minute stretch.

Acknowledgements

I'm very thankful to Prof. Dr. Faten Hassan Abdelaziem the main supervisor of this work. No words can express thanks for her guidance and support.

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Volume 4 Issue 6 June 2021