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Instantaneous effect of prolonged stretch on monosynaptic excitability in hemiplegic cerebral palsied children: Repeated measures design

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ABSTRACT
Background: Spastic CP is the most common motor impairment type of all cases of CP. This study aimed to evaluate changes of motor neuron excitability and to clarify the instantaneous effect resulting from consequent repetitive sessions of passive stretching applied to the planter flexor muscles of spastic hemiplegic cerebral palsied children. Methodology: Twenty children of spastic hemiplegic cerebral palsied aged from 4 to 6 years participated in this study as a one group. They were subjected to measure the ratio of Huffman reflex to myotatic reflex (H/M ratio) using computerized electromyographic (EMG) apparatus. It was measured from triceps soleus muscle. It was done before and after applying stretching using Knee-ankle foot orthoses. The after stretching measurements done after 30 min, one hour of stretching, and two hour of stretching. Results: The results revealed a significant reduction in H/M ratios. The results also showed a significant increasing in this reduction by increasing the time of stretching. Conclusion: From the obtained results it can be concluded that the prolonged stretch had an instantaneous reductive effect on motor neuron excitability and this effect increased by increasing the time of stretch.

Keywords: *Spasticity, prolonged stretching, H/M ratio*

1. Introduction
Cerebral palsy (CP) is the term for a range of non-progressive syndromes of posture and motor impairment that results from an insult to the developing central nervous system (Koman et al., 2004, Sankar and Mundkur, 2005). Spastic cerebral palsy is further subdivided into three types based on the affected muscles. Hemiplegia that involves the arm and leg on one side of the body but arm more affected than leg; diaplegia that involves four limbs but legs more than arms and quadriplegia that involves four limbs affected equally (Sankar and Mundkur, 2005., Hary et al., 2003). Spasticity has been defined as a velocity-dependent increase in resistance to stretch. It

is also commonly associated with hypertonicity, hyperreflexia, clonus and spread of contraction beyond the muscle stimulated (Rekand, 2010, Tilbor, 2006).

There are several approaches have been used for the treatment of CP, which include drug therapy, surgical and therapeutic interventions. In conjunction with these interventions, orthoses continue to play an important role in the physical management of children with CP. Orthoses are designed with one of two primary aims: either to affect the body structure or to assist function, although for children with CP, orthoses are frequently designed to achieve both of the these aims (Borzoo et al., 2014., Jeong et al., 2013., Dimitrijevic and Jocic-Jakubi, 2005., Morris, 2002).

Casting and splinting are two interventions that provide a prolonged stretch and have been shown to be effective in preventing of reducing knee and ankle contractures in children with cerebral palsy. Positioning such as lying prone, standing in standing tables, and sitting with hips abducted, also can provide a prolonged stretch (Cadenhead et al., 2002).

Muscle stretching is commonly used in rehabilitation programs and sports activities. Static or slow stretching methods are thought to be useful for injury prevention and improve performance by increasing the joint range of motion (i.e., flexibility). The acute response to static stretches has been related to both mechanical and neural factors (Guissard, and Duchateau, 2004., Olney and Wright , 2000., Holt et al., 2000).

The prolonged muscle stretch can reduce spasticity and improve the function of the antagonist, but they don't describe the change in reflexes. Furthermore the effective duration of a single passive muscle stretch for the spastic muscle has not applied (Tsai et al., 2001). So this study aimed to investigate the instantaneous effect of prolonged muscle stretch on monosynaptic excitability by applying ankle foot orthoses on planter flexors muscles in spastic hemiplegic cerebral palsied children.

2. Material and methods

2.1. Subjects

Twenty spastic hemiplegic cerebral palsied children from both sexes (8 males and 12 females) participated in this study. Their age's mean ranged from 5.17 ±0.65 years old. They were selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University, Abu El Rich Hospital and the Institute of Neuromotor System-Imbaba. This study was conducted in the period from September 2005 to March 2007. They were selected according to the following criteria:

- All children had mild to moderate spasticity, ranging from 1 to 2 grades according to the Modified Ashworth scale table (1), (Satkunman, 2003).
- They had no significant visual and auditory disorders.
- They had neither musculoskeletal deformities nor contractures.
- All patients were not under antispastic medication.
- The measurements of this study were obtained from the affected side.

The study was approved by an Ethics Committee of the Cairo University. Child's parents were provided with a Volunteer Information Sheet and written consent informing them about the purpose of the study, its benefits and inherent risks and their committee with regard to time and money.

2.2. Instrumentations

2.2.1. Modified Ashowrth scale:

It used for determining the degree of spasticity (Satkunman, 2003), table (1).

Table (1): Modified Ashworth Scale.

Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by catch and release or minimal resistance at the end of the range of motion when the affected part is moved in flexion or extension/ abduction or adduction, etc.
1+	Slight increase in muscle tone, manifested by catch and release or minimal resistance throughout the remainder (less than half) of the range of motion.

2	More marked increase in muscle tone through most of the range of motion, but the affected part is easily moved.
3	Considerable increase in muscle tone, passive movement is difficult.
4	Affected part is rigid in flexion or extension/ abduction or adduction, etc.

2.2.2. Computerized electromyographic (EMG) apparatus:

Neuroscreen plus version 1.59 produced by Toennies, a division of Erich Jseger Gmbh, Germany; 1998. It is used to determine motor neuron excitability.

2.2.3. Stop watch and medium gel.

2.2.4. Knee-ankle foot orthoses:

It was used to apply stretching for planter flexor muscles. Knee ankle foot orthosis was composed of knee splint and fixed ankle foot orthosis which allow no motion to occur, was designed in a few degrees (5-7º) of dorsiflexion. It is a light weight plastic L-shaped device. The short arm of the L-shape is termed footplate which refers to the portion of the orthosis in contact with the plantar surface of the foot. As the footplate extended all the way to the end of the toes to provide additional support so, the term toe plate is added to the description. The long part of this L-shaped device extended behind the ankle to about 15 cm long on the posterior aspect of the leg. Straps, made of Velcro, attach the orthosis to the limb, were tightly fastened to enhance alignment, limit motion, and provide additional stability.

2.3. Procedures

- Firstly, we detect the H/M ratio value for the child (Abdel Gawad et al., 2015), Fig (1a).
- The stretch technique was conducted by using knee ankle foot orthosis on three intervals (half an hour, one hour and two hours) as follows, Fig (1b):
- The child wear knee ankle foot orthosis for half an hour on the tested limb then the H/M value was measured after taken off the orthosis.
- The same procedure was repeated on time interval of one and two hours.
- Care was taken that:
- Before running the study, the whole procedures was explained to child's parents, gain the child confidence and fined goal friendship
- During wearing the orthosis, the children kept in supine lying position trying to enjoy themselves (by looking at children books, play with small toys, etc.
- Any changes in the setup of the study, the whole procedure was canceled, and then start from the beginning.

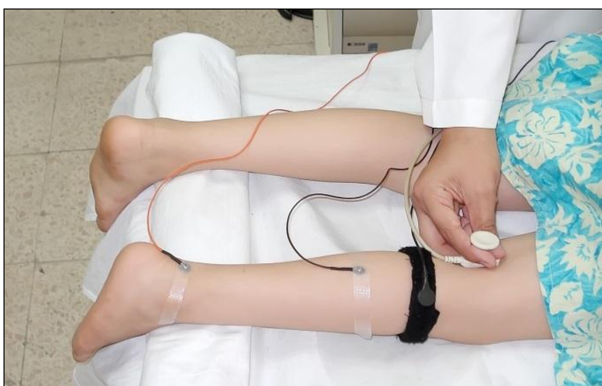

Figure (1a): Detect of the H/M ratio.

Figure (1b): Knee ankle foot orthosis.

2.4. Statistical analysis

The mean value and standard deviation were calculated for each measured variable during this study. Comparative studies were conducted between the mean differences of H/M ratio of before and after measurements by using analysis of variance (ANOVA). We used level of significance as 0.05. In case of significant, least significant difference test (LSD) was conducted to detect the location of this significant difference. All these tests were conducted at the 0.05 P level.

Results

3.1. Descriptive statistics

The general characteristics of the subjects conducted in this study including degree of spasticity and frequency of affected side for the subjects were represented in table (2). The mean value and SD of H/M ratio for the data collected (before stretching, after 30 minutes of stretching, after one hour of stretching and after two hour of stretching) were calculated and represented in table (3).

Table (2): Descriptive data for the age and degree of spasticity for the subjects conducted in this study.

Item	Degree of spasticity			Affected side	
	1	1+	2	Right	Left
Frequency	2	16	2	13	7

Table (3): The mean value and SD of H/M ratio for the data collected.

Items	Min	Max	X	SD
Before stretching	2.3	12.8	4.64	2.833
After 30 minutes of stretching	1.2	10.0	3.235	2.439
After one hour of stretching	1.0	9.8	2.585	2.355
After two hour of stretching	0.5	6.3	1.235	1.546

Min: minimum Max: maximum X: mean SD: standard deviation

3.2. Analysis of variance for the H/M ratio changes.

The percentages of the H/M ratio reduction were statistically treated by analysis of variance (ANOVA) test. The results showed a significant difference among them (F= 7.314) ($P < 0.0001$) at the 0.05 levels as shown in table (4). The least significant difference (LSD) test was conducted. The result was represented at 0.05 levels. Significant difference was observed as represented in table (5).

Table (4): Analysis of variance of the percentages of H/M ratio reduction.

Source of variation	Degrees of freedom	Sum Squares	Mean Squares	F	Significance
Treatment (between columns)	3	120.18	40.060	7.314	0.0001 Significant
Residual (within columns)	76	416.26	5.477		
Total	79	536.44			

Table (5): The least significant difference (LSD).

Items	Mean difference	P value
Before and after 30 minutes stretching	1.405	P>0.05
Before and after one hour stretching	2.055	P<0.05*
Before and after two hour stretching	3.405	P<0.001*
After 30 minutes stretching and after one hour stretching	0.6500	P>0.05
After 30 minutes stretching and after two hour stretching	2.000	P<0.05*
After 1 hour stretching and after two hour stretching	1.350	P>0.05*

*The mean difference is significant at the 0.05 level.

Discussion

The instantaneous effect of prolonged stretch on monosynaptic excitability in hemiplegic cerebral palsied children is the issue of the present study. The age of the children in the present study was ranged from four to six years as H-reflex is widely distributed in infants younger than 2 years old (Shin., 2003).

According to the above results, it can be suggested that the use of prolonged stretch as an essential part of the physiotherapy interventions may be effective in reducing the motor neuron excitability in case of spasticity. Also it can be suggested that the reduction of the motor neuron excitability in case of spasticity increased by increasing the time of prolonged stretch applied for the spastic muscle.

The reduction of the spasticity obtained in this study confirm the finding of Katz, (1988) who stated that positioning the limb in atonic stretch had been observed to decrease reflex tone. The long-term casting resulted in a significant decrease in both dynamic and static reflex sensitivity (Katz, 1998).

The results of this study supported by Tremblay et al., (1990) who showed that prolonged muscle stretch led to significant reduction of spasticity in ankle muscles and these inhibitory effects lasted up to 35 min after cessation of passive muscle stretch (Tremblay, 1990). The results of this study come in agreement with Tsai et al., (2001) who showed that the passive ROM of ankle dorsiflexion increased significantly compared to that before prolonged muscle stretch. Additionally, prolonged muscle stretch reduced motor neuron excitability (H/M ratio) of the plantar flexor muscles and significantly increased F/M ratio of the tibialis anterior.

The results also supported by Tardieu, (1987) who confirmed that casting immobilizes the joints and muscle for periods of time, and this can affect muscle and connective tissues mechanics in addition to neural mechanisms of spasticity.

The significant reduction of mean values of H/M ratio and consequently decreasing of the spasticity after prolonged stretch may be due to activation of the inhibitory mechanisms at both spinal, and supraspinal levels. Activation of the inhibitory mechanisms at spinal level is obtained by increased proprioceptive inputs that are provided through the application of prolonged stretch. It could be effective in stimulation of spinal inhibitory mechanisms such as autogenic inhibition via Ib inhibitory interneurons and stimulation for Group II afferent fibers (Richards et al., 1991., Odeen and Knutsson, 1981).

In this work, the somatic proprioceptive sensory information result from prolonged stretch might stimulate the reticular formation. The inhibitory reticular formation projects downward to the spinal cord with little inhibition effect projecting up to the cortex, basal ganglia and the red nucleus. The stimulation of reticular formation might improve the arousal level and awareness of the sensation that probably help the brain in producing coordination and harmonious interactions between supraspinal facilitatory and inhibitory centers controlling spinal interneurons and motor neurons for modulating muscle tone and motor response (Kandel, 2013., Schafer, 1984).

Conclusion

From the obtained results, it can be concluded that the prolonged stretch had an instantaneous reduction effect on motor neuron excitability in case of spastic cerebral palsied children and this effect increased by increasing the time of stretching.

Disclosure

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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