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ACUTE EFFECTS OF INTRAMUSCULAR STRETCHING AND PASSIVE STRETCHING ON SPASTICITY IN CHILDREN WITH CEREBRAL PALSY

ORIGINAL ARTICLE

ABSTRACT

Purpose: Several methods are used to reduce spasticity in cerebral palsy (CP) rehabilitation. One of these methods is stretching. This study aimed to compare the acute effects of intramuscular stretching and passive stretching on spasticity in children with bilateral spastic CP.

Methods: The study included a total of 22 children (12 boys and 10 girls) with bilateral CP, between the ages of 5 and 13 years (mean age=6.45±1.96 years), who had spasticity in the plantar flexor muscle groups. All children were under an individualized physiotherapy program. In addition to the physiotherapy program, intramuscular stretching was applied to the plantar flexor muscles on one side, whereas passive manual stretching was applied to the other side. The Modified Ashworth Scale (MAS), Modified Tardieu Scale (MTS), and Silfverskiold test were used to assess the spasticity. Evaluations were performed before and after the applications.

Results: There was a significant difference between pre and post-treatment comparisons in the intramuscular stretching side (MAS p=0.024, MTS R2-R1 p<0.001, Silfverskiold test p=0.002) and the passive stretching side (MAS p=0.014, MTS R2-R1 p=0.001, and the Silfverskiold test p=0.003). On the other hand, there was no difference between the intramuscular and passive stretching sides (p>0.05).

Conclusion: Both intramuscular and passive stretching are effective methods for reducing spasticity in children with bilateral spastic CP, and their acute effects are similar.

Key Words: Cerebral Palsy; Massage; Muscle Spasticity; Muscle Stretching Exercises; Muscle Tone.

SEREBRAL PALSİLİ ÇOCUKLARDA KAS İÇİ GERME İLE PASİF GERME YÖNTEMLERİNİN SPASTİSİTE ÜZERİNE AKUT ETKİLERİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Serebral palsi (SP) rehabilitasyonunda spastisiteyi azaltma amacıyla birçok yöntem kullanılır. Bu yöntemlerden birisi de germe uygulamalarıdır. Bu çalışmanın amacı bilateral spastik tip SP'li çocuklarda kas içi germe ve pasif germenin spastisite üzerine akut etkilerini karşılaştırmaktı.

Yöntem: Çalışmamıza 5-13 yaş arasında (12 erkek ve 10 kız çocuk, ortalama yaş=6,45±1,96 yıl), plantar fleksör kaslarında spastisitesi olan, bilateral spastik tip SP'li çocuklar dâhil edildi. Tüm çocuklara kişiye özel fizyoterapi programı uygulanmaktaydı. Çocukların fizyoterapi programına ek olarak bir taraf plantar fleksör kas grubuna kas içi germe uygulanırken, diğer taraf plantar fleksör kas grubuna pasif germe uygulandı. Spastisite değerlendirmeleri Modifiye Ashworth Skalası (MAS), Modifiye Tardieu Skalası (MTS) ve Silfverskiold testi ile yapıldı. Değerlendirmeler uygulamalardan önce ve sonra yapıldı ve iki taraf değerleri birbiri ile karşılaştırıldı.

Sonuçlar: Tedavi öncesi ve sonrası değerleri karşılaştırıldığında kas içi germe yapılan tarafta (MAS p=0,024, MTS R2-R1 p<0,001, Silfverskiold test p=0,002) ve pasif germe yapılan tarafta (MAS p=0,014, MTS R2-R1 p=0,001, Silfverskiold test p=0,003) anlamlı fark görüldü. Ancak iki taraf arasında anlamlı fark yoktu (p>0,05).

Tartışma: Bilateral spastik tip SP'li çocuklarda kas içi germe ve pasif germe yöntemleri spastisiteyi azaltmakta etkili yöntemlerdir ve akut etkileri benzerdir.

Anahtar Kelimeler: Serebral Palsi; Masaj; Kas Spastisitesi; Kas Germe Egzersizleri; Kas Tonusu.

INTRODUCTION

Cerebral palsy (CP) is the most common cause of childhood disability globally (1). The primary brain insult is non-progressive; the secondary musculoskeletal impairments are progressive (2). One of the disorders seen in children with CP is abnormal muscle tone. Spasticity is resistant to the passive movement of the extremity, depending on the velocity. In the vast majority of children with CP, psychomotor factors affect development, resulting in loss of performance and motor retardation (3). According to the International Classification of Functioning, spasticity, which is defined as a disorder, also causes significant limitations in the activity and participation (4).

Spasticity seen in children with spastic CP is the leading cause of diminished longitudinal muscle growth and malfunction, and this leads to the formation of deformities. Weakness and hypertonus cause an imbalance between agonist and antagonist muscles, which is initially dynamic, i.e., reversible with passive manipulation, but may lead to contracture over time (5). Increased muscle tone causes pain, bone lesions, fragility, and deterioration in ambulation (3). Muscle stiffness has been used to describe various morphological and mechanical properties of the muscle, such as elasticity, viscosity, or even shortening (6). Increased muscle stiffness in CP, therefore, refers to alterations to the tissue's mechanical properties, and contracture is defined as "a decrease in muscle length and an increase in passive muscle stiffness" (7,8).

Several methods are used to reduce spasticity in CP rehabilitation. One of these methods is stretching (9). Physiotherapists use a variety of stretching strategies, such as passive stretching and active stretching (9-11). In addition to these methods, interventions such as orthosis and serial casting may be applied or surgical interventions to reduce muscle tension and spasticity (12). In recent years, studies have been progressed from passive methods to active and functional approaches in stretching programs (11,13,14). Stretching exercises create mechanical changes in the musculotendinous unit, reducing spindle sensation and gamma activity, relieving muscle tension, and reducing susceptibility (15). Spasticity is generally worse in the lower limbs in children with bilateral cerebral palsy, and it is observed in many muscles such as gastrocnemius, soleus, adductors, hamstrings, psoas, and rectus femoris (16,17). The plantar flexor muscles are commonly affected in children with spastic CP (17). A previous study showed that children with CP have stiffer tendons than their typical peers, and they experience significant alterations in soft tissue structures within the muscle-tendon unit. Muscle-tendon unit stiffness is affected by several structures surrounding the corresponding joint, including muscles, tendons, ligaments, and muscle fascia (18). Therefore, stretching should be performed, including all muscle fibers from the outer surfaces to the deep of the muscles. Intramuscular stretching involves stretching to mobilize whole fibers of the targeted muscle, and it is performed with deep massage through the entire fiber from the origin to the insertion (19).

The effects of passive stretching on spasticity have been investigated (18,20). The effects of massage on spasticity have also been shown in several studies (21,22). A previous study reported that although there was no increase in regular joint movements of children with CP after a massage, it was observed that gross motor functions improved with ambulation (21). There has been no study showing the results of intramuscular stretching by mobilization in the literature. Therefore, this study aimed to investigate and compare the acute effects of intramuscular stretching and passive stretching on spasticity in children with bilateral spastic CP. We hypothesized that stretching applications would reduce spasticity acutely in children with CP, and intramuscular stretching would be more effective than passive stretching.

METHODS

Participants

The study included a total of 22 children with bilateral spastic CP, between the ages of 5 and 13 years, in level III, IV, and V according to the gross motor function classification system expanded and revised (GMFCS E&R) with spasticity in the plantar flexor muscle groups. Children cooperating in the stretching applications and tests were included

in the study. Children who had botulinum toxin injection and surgery in the last six months and had joint limitations were not included in the study.

All the children were treated and evaluated by the same physiotherapist (KUA) experienced for 10 years in the field of pediatrics.

Study Design

This study was designed as a cross-sectional study. The study was carried out at the Pediatric Rehabilitation Unit, Physiotherapy and Rehabilitation Department, Gazi University. The children were recruited from April 2016 to March 2017. Approval for the study was granted by Gazi University Clinical Research Ethics Committee (Approval Date: 26.02.2016 and Approval Number: 25901600-69). Written informed consent was obtained from the parents or legal guardians of all the study participants.

All children were under an individualized physiotherapy program consisting of 45-min sessions twice a week. The individualized physiotherapy program was planned, including positioning, functional strengthening, weight shift, and balance-coordination exercises according to every child's needs. Assessments and stretching methods were applied to children on the day they did not participate in a physiotherapy session. In order not to affect the results of the evaluations performed, orthoses were not used in children before stretching applications and evaluations.

Intramuscular stretching was applied to the plantar flexor muscle groups on one side, whereas passive manual stretching was applied to the other side in lying position. In applications, the coin toss method was used to decide which side of the child to apply intramuscular stretching and which side of the passive stretching method.

Evaluations were performed before and after one session of stretching, and the comparison was made accordingly.

Assessment

After recording the demographic data, GMFCS E&R (23) was used to classify the children's gross motor functions with CP. The GMFCS E&R describes the locomotor abilities of children with CP in five levels. At Level I, children can generally walk without restrictions but tend to be limited in more advanced motor skills. At Level V, children are generally very limited in their ability to move around, even with assistive technology. For each level, the GMFCS E&R classifies gross motor functions for different age groups (<2, 2-4, 4-6, 6-12, and 12-18 years), as motor functions vary with age (23). The Turkish version of GMFCS E&R was used for this study (24).

The Modified Ashworth Scale (MAS) is the most widely used scale to measure spasticity in children with CP, despite problems with validity and reliability (25). The amount of resistance that a muscle shows during rapid passive movement of the extremity are determined manually. There are five levels; 0, 1, 1+, 2, 3, and 4. Level 0 refers to no tone increase, and Level 4 refers to rigidity in flexion or extension (26).

Modified Tardieu Scale (MTS) is another measure used to assess spasticity. The MTS is a 6-point rating scale, and it includes two parameters, X and Y. Two velocities were chosen to determine the quality of muscle reaction, such as slow as possible (V1) and as fast as possible (V3). The scale consists of two parts. In the first part (X parameter), a value between "0" and "5" is given to the amount of spasticity manually at two different speeds with 0 indicating no resistance during passive movement, "4" indicating that the clonus forms fatigue lasting longer than 10 seconds, which occurs at a specific angle when pressure is maintained and "5" indicating joint immovable. In the second part (Y parameter), R2 was defined as the full ROM during a slow-velocity stretch (V1), and R1 was defined as the threshold angle of catch-and-release or clonus at a fast speed of stretch (V3). A massive difference between R1 and R2 implies a large dynamic component (26). In the current study, R1 and R2 values were measured using a goniometer. The Silfverskiold test was used in some studies to differentiate the gastrocnemius and soleus muscles in children with CP (27,28). In the supine position, ankle dorsiflexion range was measured using a goniometer with the knee and hip fully extended on the tested side and passively in 90° flexion. Less dorsiflexion when the knee is in extension indicates the shortness of the gastrocnemius and spasticity (29). When measuring the ankle dorsiflexion, care

was taken to keep the foot in inversion.

The muscle tone assessments were performed by the same physiotherapist who had experience in the field of pediatric rehabilitation for 10 years. Each child was evaluated in the supine position on the bed in a quiet room with the parents' presence when they are calm and are not hungry. The evaluation period lasted approximately 30 minutes before and after the treatment.

Treatment

Intra-muscular stretching of the plantar flexor muscles was applied for 10 minutes while the child was in the prone position. Intramuscular stretching was performed with deep massage and soft tissue mobilization and the entire fiber towards the muscle's insertion while the child was in a relaxed position. Both hands were placed on the muscle, and the muscle fibers were gripped. Simultaneously, pulling one hand in the medial direction, pushing the other hand in the lateral direction aimed to lengthen the muscle (Figure 1) (19). Deep massage can stretch the muscle that experiences spasticity and reset sarcomere lengths to a more optimal state. It helps break down subcutaneous adhesions and prevent fibrosis (30) and may lead to improved proprioceptive feedback from muscle spindle receptors (21).

On the other leg, the child was held in the supine position; muscle was stretched to the end range of the dorsiflexion passively, held 15 seconds in the elongated position, and 15 seconds in the rest position a total of 10 minutes. The pressure at the ankle continued to be applied until the participant indicated a point of discomfort. Twelve repetitions of each stretch being held (14,31).

Statistical Analysis

According to the reference study (14) results, a power analysis was performed before the study by assuming that we could achieve a strong effect size. For this effect size level (d=0.90), if there were at least 16 subjects in each group (at least 32 children at total), our study could reach 80% power at 95% confidence level. Considering the possible loss of subjects, 15% more subjects were included in each group, and the study was completed with 22 people in each group. SPSS Statistics 21.0 (IBM SPSS Statistics for Windows, Version 21.0. IBM Corp., Armonk, USA) was used to assess the data obtained from the study and to prepare the tables. The normal distribution of variables was examined visually (histogram and probability plots) and with analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk tests). Descriptive analyses were performed using mean and standard deviations for normally distributed variables, and median and quartile intervals for non-normally distributed and ordinal variables. To compare the pre- and post-treatment data, the Wilcoxon signed-rank test was used. In the comparisons of two groups, the Mann-Whitney U test was used. A p-value of less than 0.05 was considered to show a statistically significant result.

RESULTS

The study included a total of 22 children with bilateral spastic CP, between the ages of 5 and 13, in level III, IV, and IV according to the GMFCS E&R with spasticity in the plantar flexor muscle groups. According to the GMFCS E&R, 13.6% were at level III, 40.9% at level IV, and 45.5% at level V (Table 1).

Table 1: Characteristics of the Subjects.

Demographic Parameters	Subjects (n=22)	
	Mean±SD	Min-Max
Age (years)	6.45±1.96	5-13
Height (cm)	108.00±13.12	100-131
Weight (kg)	17.00±8.24	14-32
	n	**%**
Gender (Female/Male) (n, %)	10/12	45.5/54.5
GMFCS E&R (n, %)		
Level III	3	13.6
Level IV	9	40.9
Level V	10	45.5

GMFCS: Gross Motor Function Classification System.

Table 2: Comparison of Intramuscular Stretching Side and Passive Stretching Side Pre- and Post-Treatment.

Variable	Intramuscular Stretching			Passive Stretching		
	Pre-treatment Median (25-75 IQR)	Post-treatment Median (25-75 IQR)	p	Pre-treatment Median (25-75 IQR)	Post-treatment Median (25-75 IQR)	p
MAS	2 (2-3)	2 (1.5-3)	0.024*	2 (2-3)	2 (1.5-3)	0.014*
MTS (X V1)	2 (1-2)	1 (1-2)	0.011*	2 (1-2)	1 (1-2)	0.022*
MTS (X V3)	2 (2-3)	2 (2-2)	0.007*	3 (2-3)	2 (2-3)	0.025*
R1	-2.5(-8.5-6.25)	2 (-2.25-10)	<0.001*	-1 (-7.5-10)	4 (-2.25-12)	<0.001*
R2	10 (5-16)	13 (9.5-18)	<0.001*	10 (6-17.25)	14.5 (9.5-20)	<0.001*
R2-R1	10 (7.75-14)	9 (5.75-10)	<0.001*	9 (6.5-12.75)	8 (5-12)	0.001*
Silfverskiold Test	18 (14.75-20)	20(18-20)	0.002*	19 (14.75-20)	20 (18-20)	0.003*

*p<0.05. Wilcoxon test. MAS: Modified Ashworth Scale, MTS: Modified Tardieu Scale, X V1: as slow as possible, X V3: as fast as possible.

Figure 1: Intramuscular Stretching.

There was no difference between the sides before treatment in terms of MAS, MTS, and the Silfverskiold test (p>0.05). A significant difference was observed between pre and post-treatment scores in the intramuscular stretching side with respect to MAS (p=0.024), MTS (X V1) (p=0.011), MTS (X V3) (p=0.007), R1 (p<0.001), R2 (p<0.001), R2-R1 (p<0.001), and Silfverskiold test (p=0.002) (Table 2). A significant improvement was observed between pre- and post-treatment scores in the passive stretching side in terms of MAS (p=0.014), MTS (X V1) (p=0.022), MTS (X V3) (p=0.025), R1 (p<0.001), R2 (p<0.001), R2-R1 (p=0.001), and the Silfverskiold test (p=0.003) (Table 2). There was no difference between the two sides, and the efficacy of the treatments was similar (p>0.05) (Table 3).

DISCUSSION

Based on our findings, intramuscular stretching and passive stretching are effective methods for acutely reducing the spasticity and muscle tension of plantar flexor muscles in children with bilateral spastic CP. However, there was no difference between these two methods.

Stretching applications are used to reduce spasticity in CP rehabilitation. Acutely, passive stretching has been shown to increase ROM in children with CP (14,31). Kalkman et al. (14) reported an acute increase in joint range of motion after passive stretching, but no change in muscle fascicles is lengthening and torque. Theis et al. (31) examined the acute effects of passive stretching on muscle fascicle length in children with CP. The authors reported that the length of muscle and fascicle increased immediately after passive stretching. Another study by Theis et al. (18) studied the effects of long-term passive stretching methods on muscle-tendon unit mechanics in children with CP and reported that passive stretching could reduce muscle stiffness by altering fascicle strain but not resting fascicle length. Novak et al. (32) reported that manual stretching was an ineffective method to prevent contractures. In our study, it was observed that in children with CP, passive range of motion increased, spasticity decreased after passive stretching.

Massage and mobilization applications are also used in addition to exercise in CP rehabilitation. Massage assists in circulation, and lymphatic drainage enhances the elastic and inelastic properties of connective tissue and muscle, increases flexibility, fosters relaxation, and alleviates muscle pain (33). Macgregor et al. (21) investigated the mechanical effects of massage on muscles in adolescents with spastic diplegia. The range of movement was not consistently increased, but there

Table 3: Change in Scores between Intramuscular Stretching Side and Passive Stretching Side.

Variables	Intramuscular Stretching (Mean±SD)	Passive Stretching (Mean±SD)	p
ΔMAS	0.22±0.36	0.27±0.42	0.619
ΔMTS (X V1)	0.36±0.58	0.18±0.36	0.221
ΔMTS (X V3)	0.41±0.59	0.22±0.42	0.263
MTS R1	4.13±2.6	4.22±2.99	0.934
MTS R2	2.51±1.89	2.54±1.43	0.722
MTS R2-R1	1.72±1.51	1.68±2.05	0.563
ΔSilfverskiold Test	1.63±1.78	1.51±1.76	0.821

Mann Whitney U Test. MAS: Modified Ashworth Scale, MTS: Modified Tardieu Scale, X V1: as slow as possible, X V3: as fast as possible.

were observed to be improvements in proprioceptive sensation with changes in the sarcomere structure, decreased abnormal stretching reflexes, increased voluntary ankle rotation, and improvements in motor skills. In a study by Malila et al. (22), the effect of Thai massage on spasticity was examined in young individuals with CP, and it was concluded that Thai massage could reduce spasticity and may be applied as an alternative treatment method. The effects of deep friction massage on spasticity were investigated by Rasool et al. (34), and although there was no change in the functional levels of children, the spasticity scores decreased after treatment. Mahmood et al. (35) reported that traditional massage could effectively reduce spasticity, does not have harmful effects so that it can be administered safely by mothers at home. They reported that traditional massage does not develop gross motor function. In our study, an intramuscular stretching was applied to one extremity of each child. Intramuscular stretching is a method involving manual exercises to mobilize the whole muscle, not just a specific region of the muscle, and it is performed with deep massage through the entire fiber from the origin to the insertion. Our study showed that as a result of intramuscular stretching, there was an immediate increase in the range of motion, spasticity decreased, but there was no difference between the two methods.

The present study had some limitations. We investigated the acute effects of stretching methods on spasticity. There is a need for further study with an increased sample size and longer follow-ups. Studies with chronic outcomes investigating effects of exercises on functionality, spasticity may provide more robust results. One of the disadvantages of our study was that children might slack because they were tired after treatment and evaluation. Another limitation of our study was that physiotherapist who performed and evaluated the treatment was the same. The last limitation of our study was that no additional spasticity assessment was performed for the soleus muscle.

In conclusion, this was the first study to have evaluated the effects of intramuscular stretching in children with CP. Intramuscular stretching, which is less painful than passive stretching, could be considered a safe, alternative method for the prevention of spasticity commonly seen in children with CP. In addition, we thought that the use of intramuscular stretching and mobilization methods in CP rehabilitation might add a dynamic feature to the treatment. Further studies comparing the long-term impacts of intramuscular stretching are needed.

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Conflict of Interest: The authors report no conflict of interest.

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Informed Consent: Written informed consent was obtained from the parents or legal guardians of all the study participants.

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