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ORIGINAL ARTICLE

Effects of functional massage on spasticity and motor functions in children with cerebral palsy: a randomized controlled study

Hasan BİNGÖL[1,2], Özlem YILMAZ[3]

Purpose: The purpose of this study was to investigate the effects of functional massage on the severity of lower limb spasticity and gross motor function of children with cerebral palsy (CP).

Methods: In this study, 20 children who were classified as level I-IV according to Gross Motor Classification System (GMFCS), who had communication skills (according to Communication Function Classification System, level I-III), who had never undergone surgery and who were between the ages of 5-12 years, were recruited from two rehabilitation centers. Children were randomized to control or experimental groups to receive either only Traditional Physiotherapy (TP) or TP combined with Functional Massage (FM). Interventions were delivered at equal dosage (total eight weeks, 2 days per week, 45 minutes/day) in the same environment. The severity of spasticity was measured with Modified Ashworth Scale (MAS), and functional level and gross motor function were quantified according to GMFCS and Gross Motor Function Measure (GMFM), respectively.

Results: When the pre-therapy and post-therapy data covering GMFM and hip adductors, hip flexors, hamstrings and calf muscles spasticity score of the both groups were compared, no statistically significant difference was determined in the hip flexor spasticity score of the control group ($p>0.05$), while considerable differences were defined in the hip flexors spasticity score of the experimental group ($p<0.05$). Improvements on MAS belonging to other three muscle groups and on GMFM score were similar in both groups ($p>0.05$).

Conclusion: In conclusion, it was identified that FM combined with TP is effective in treating spasticity and in improving some parameters related to motor function in children with CP.

Keywords: Cerebral palsy, Muscle spasticity, Massage therapy.

Fonksiyonel masajın serebral palsili çocuklarda spastisite ve motor fonksiyon üzerine etkileri: rastgele kontrollü çalışma

Amaç: Bu çalışmanın amacı; fonksiyonel masajın serebral palsili (SP) çocukların alt ekstremite spastisite şiddetine ve kaba motor fonksiyonlarına etkilerini araştırmaktı.

Yöntem: Çalışmaya iki farklı rehabilitasyon merkezinden, iletişim becerisi olan (İletişim Becerileri Sınıflandırma Sistemine göre iletişim becerileri I-III arasında), fonksiyonel seviyeleri Kaba Motor Fonksiyon Sınıflandırma Sistemi'ne (KMFS) göre I-IV arasında değişen, hiç ameliyat geçirmemiş ve yaşları 5-12 yaş arasında değişen 20 SP'li çocuk dahil edildi. Çalışmaya dahil edilen çocuklar kontrol veya araştırma gruplarına sırasıyla sadece Konvansiyonel Fizyoterapi (KF) veya KF'ye ek olarak Fonksiyonel Masaj (FM) almak üzere rastgele dağıtıldı. Uygulamalar gruplara aynı ortamda ve eşit dozlarda verildi (toplam sekiz hafta, haftada 2 gün, günde 45 dk). Spastisite şiddeti Modifiye Ashworth Skalası (MAS), fonksiyonel seviye ve kaba motor fonksiyonlar sırasıyla KMFS ve Kaba Motor Fonksiyon Ölçütü (KMFÖ) ile değerlendirildi.

Bulgular: Her iki gruba ait terapi öncesi ve terapi sonrası KMFÖ, kalça fleksörleri, adduktörleri, hamstringler ve baldır kaslarının spastisite skorlarını kapsayan veriler karşılaştırıldığında, kontrol grubuna ait kalça fleksörleri spastisite skorunda herhangi bir fark bulunmazken ($p>0.05$); araştırma grubuna ait kalça fleksörleri spastisite skorunda iyileşme saptandı ($p<0.05$). MAS'daki diğer üç kas grubuna ait spastisite skorunda ve KMFÖ skorundaki değişimler her iki grup için benzerdi.

Sonuç: Sonuç olarak, SP'li çocuklarda FM'nin KF ile kombinasyonu spastisitenin tedavisinde ve motor fonksiyonlarla ilgili bazı parametreleri iyileştirmede etkili olduğu sonucuna varılmıştır.

Anahtar kelimeler: Serebral palsi, Kas spastisitesi, Masaj tedavisi.

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1: Muş Muş Alparslan University, School of Health Services, Department of Therapy and Rehabilitation, Muş, Türkiye.
2: Hacettepe University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Türkiye.
3: Haliç University, School of Health Services, Department of Physiotherapy and Rehabilitation, Istanbul, Türkiye.
Corresponding Author: Hasan Bingöl: hesenbingol@gmail.com
ORCID ID: 0000-0003-3185-866X
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Cerebral palsy (CP) is one of the most common childhood disabilities, and it occurs with an incidence of 2-2.5 per 1000 living births.[1] Children with CP have various impairments including neuromuscular and musculoskeletal problems such as spasticity, dyscoordination, loss of selective motor control, and weakness. In addition, spasticity can cause joint contracture through increased muscle stiffness.[2] Spasticity is one of the most common problems in children and adults with CP. Damage to descending pathways results in several forms of motor and sensory disorders and typically causes spasticity, which is a characteristic of upper motor neuron lesions.[3] A widely accepted definition of spasticity is the increase in the velocity-dependent joint resistance of the muscle to passive motion. Spasticity is an important phenomenon that may cause functional limitations, pain and secondary complications.[4] However, it is still unknown whether spasticity is associated with muscle strength.[5]

Two hypotheses have been proposed to account for the features of spasticity. One hypothesis is that the mechanical abnormalities are due to hyperactive stretch reflexes because tendon jerks and reflex electromyograms (EMGs) increase spasticity.[6] The alternative hypothesis is that these mechanical abnormalities result from changes in the intrinsic mechanical properties of spastic muscles and/or passive tissues.[7] The reason for the emergence of these incompatibilities is the lack of correct and precise measurements that distinguish causal factors from each other.[8] The previous studies attempted to distinguish between intrinsic and reflex strength or stiffness by using electrical stimulation and nerve blockages to suppress the reflex response.[9] However, these studies were not considered to be successful.[10] Despite intensive examinations, the origin and nature of mechanical changes occurring in muscles and its connection with spasticity-related tissues have not been completely understood.[11-12] As a result, both increase reflex and intrinsic factors lead to joint stiffness.[13]

There are various therapy approaches in the treatment of spasticity.[14] These approaches are effective at each stage of the disease both in improving the functions of individuals with CP and in increasing the quality of life.[15] There are no studies to date that reveal the superiorities of the current approaches used for the treatment of spasticity over each other.[16]

Thus, nowadays there is still no standard treatment approach in decreasing the severity of spasticity and muscle stiffness.[17] In a systematic review of Novak et al.[18] in which they investigated the state of the evidence of intervention for children with CP by utilizing Grading of Recommendations Assessment, Development and Evaluation (GRADE) system and Evidence Alert Traffic Light System, Massage Therapy (MT) was assigned to the "Yellow Light" level, which refers to either lower-level evidence supporting its effectiveness or inconclusive evidence.[19] Despite the mechanism of MT on treatment of spasticity was limited, two possible mechanisms have been suggested: (1) MT stretches the muscle–tendon complex and stimulates the Golgi tendon organ that could inhibit alpha motor neurons and reduce spasm[20], and (2) MT might reinforce sensory stimulation and activate the gamma efferent fibers of muscle stretch receptors that make receptors more sensitive to muscle stretch.[21] There are various types of massage therapy reported by researchers such as Thai Massage, cross friction massage, Chinese massage therapy, etc. In a study in which the effects of Thai massage on spasticity were investigated, it was concluded that Thai massage might decrease muscle spasticity among young people with CP. Additionally, the researcher suggested that Thai massage would be an alternative treatment to reduce spasticity.[22]

MT is a relatively simple, inexpensive and non-invasive therapeutic approach, and has been utilized to decline the severity of spasticity and muscle stiffness in children with CP. Clinical observation suggested that MT might be safe and effective in treating spasticity.[23-24]

Functional massage (FM) is a method of decreasing the muscle tone through reflex by alternately extending and shortening the muscle passively and also concurrently by performing petrissage and retrograde massage (classic massage) throughout fibers of muscle.[25-26] FM is a manual therapy technique that combines a rhythmical and non-painful passive joint mobilization in the direction of muscle

stretching together with compression/ decompression of the muscle to be treated.[27] In other words, FM combines the MT and passive joint movement concurrently. While applying massage therapy to a muscle group, relevant muscle group is moved concurrently from its spastic pattern position to anti-spastic pattern position.[28] The difference between MT and FM is that FM is performed in conjunction with passive motion.

Applying classic passive stretch exercise to the muscle with spasticity might lead to pain or disturbance.[29] It may be better to apply stretch exercise combined with massage therapy to spastic muscle by performing classic stretch exercise and classic massage simultaneously.[30,31] Consequently, this approach might not lead to pain or disturbance.[32] However, there is currently no satisfactory evidence that FM is effective in decreasing the severity of spasticity or treating muscle stiffness. Accordingly, based on the previous studies which suggested that MT is effective in reducing the severity of spasticity, we hypothesize that FM decreases the severity of spasticity and improves the motor function of children with lower limb spasticity efficiently. Consequently, this study was planned as a prospective randomized controlled trial to determine: (1) whether FM can decrease the severity of spasticity, and (2) whether FM improves motor function.

METHODS

The ethics consent of the study protocol was approved by the Institutional Ethical Board of Haliç University (2012/10). All study protocols and procedures were explained to each participant or their caregiver. The parents of all the participants signed an informed consent before any study-related procedure.

Participants

Children (13 quadriplegic, 4 diplegic and 3 hemiplegic) were recruited from two different rehabilitation centers. Children, who (1) were between the ages of 5 and 12 years , (2) never had undergone surgery in lower limbs, (3) were classified as level I-IV based on the Gross Motor Classification System (GMFCS), (4) had communication skills (according to the Communication Function Classification System, level I-III), were included in the study. The exclusion criteria were established: (1) the existence of dyskinesia or dystonia (2) no ability to follow instructions during the intervention and complete the testing. Before the commencement of the study, the informed consent form was obtained from each child or her/his caregiver.

Study design

The study has been planned as a prospective, controlled clinical trial investigating the efficacy of FM on spasticity and gross motor function. In this prospective study, the demographic characteristics of each children, subtype of CP, age, gender, and functional level according to the GMFCS, the severity of spasticity as measured by the Modified Ashworth Scale, and gross motor function according to the Gross Motor Function Measure (GMFM) were summarized in Table 1.

Twenty children with CP from two different rehabilitation centers were included in the study. Then, all the participants were randomly allocated to the control and experimental groups using block randomization. Outcome measures were assessed at baseline and immediately after the intervention period by experienced physiotherapists who were informed about group allocation. Interventions were applied to the patients twice a week in 45-minute sessions for two months. In the experimental group, during the first 20 minutes, ten-minute FM was applied to each lower extremity of the subjects. The muscle groups to which FM would be applied were limited with adductors, hamstring muscles, calf and hip flexors. During the remaining period, traditional physiotherapy (TP) involving conventional stretching exercises, strengthening exercises, and independent or device-assisted walking training was delivered to patients taking the impairments in their lower limbs into account. In contrast to the experimental group, the control group was given only the need-based traditional physiotherapy.

Functional massage intervention

First, the muscle to which FM would be applied was placed passively in the shortest position. Then, while the muscle which was positioned in its short position was extended passively with one hand, petrissage was simultaneously applied to muscle fibers

longitudinally with the other hand. Similarly, while the muscle was passively taken from its short position to its long position, retrograde myofascial stretching from muscle's insertion to origin was applied to the muscle. Petrissage and myofascial stretching were performed alternately.

Statistical analysis

Statistical analyses were performed using the SPSS software version 21.0. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Simirnov/Shapiro-Wilk's test) to determine whether or not they are normally distributed. Descriptive analyses were presented using means and standard deviations for normally distributed variables. Paired Student's t-test was used to compare the initial and immediate post-treatment score. The similarity between the groups in terms of age, spasticity, GMFM score, and GMFCS level was assessed using the Independent Samples t test. A p-value less than 0.05 was considered to show a statistically significant result.

RESULTS

All the subjects in this randomized controlled study, which was conducted to investigate the effectiveness of functional massage, were diagnosed with CP. In total, there were 10 subjects in the experimental group, 8 of whom were quadriplegic, 1 was diplegic, and 1 was hemiplegic CP. On the other hand, there were 10 subjects in total in the control group, 5 of whom were quadriplegic, 3 were diplegic, and 2 were hemiplegic CP. These two randomly created groups were found to be diagnostically similar in the statistical examination conducted. The two groups were statistically similar in terms of the total spasticity values for adductors, flexors, hamstrings and triceps surae muscles ($p>0.05$). Also, the comparisons revealed statistical similarity in terms of the initial GMFM scores and GMFCS values ($p>0.05$).

According to the Modified Ashworth Scale of the spasticity values of adductor muscles, flexor muscles, hamstring group muscles, and triceps surae group muscles, no statistically significant difference was found between the two groups as far as the initial values are concerned ($p>0.05$). No significant difference was determined between the initial GMFM and GMFCS scores of both groups ($p>0.05$) (Table1).

No difference was found between the pre-treatment and post-treatment spasticity scores of the control group for the hip flexors ($p_1>0.05$). In contrast, a significant difference was observed between the pre-treatment and post-treatment spasticity scores of the experimental group for the hip flexors ($p_2<0.05$). Except for the flexor muscles spasticity score of the experimental groups, there were significant differences in baseline and immediate post intervention scores of spasticity for other muscle groups in both groups ($p<0.05$) (Table 2).

Comparison of pre-treatment and post-treatment GMFM scores for both groups are statistically significant ($p<0.05$) (Table 3). However, when the differences in changes before and after the intervention were compared, the differences in the experimental group were determined to be more ($p<0.05$). On the other hand, there was no significant change in GMFCS levels before and immediately after the intervention for both experimental and control group ($p>0.05$).

We believe that the excessive increase in the GMFM scores of the experimental group may have resulted from the positive effect of the functional massage applied in addition to the conventional methods.

DISCUSSION

Our study revealed that FM was significantly effective in reducing the severity of the hip flexor spasticity. When the pre-treatment and post-treatment scores of both groups for hip flexors spasticity were compared, a significant decrease was identified only in the experimental group. Pre- and post-treatment findings revealed no difference in the control group for the same score.

When the pre-treatment and post-treatment findings pertaining to the extremities were compared, for both experimental and control groups, a similar level of significance was determined as far as the spasticity values for the calf muscles were concerned. This similar change in the calf

Table 1. Comparison of the age and initial clinical evaluation results of the groups.

	Experimental group (N=10) Mean±SD	Control group (N=10) Mean±SD	p
Age (year)	6.6±1.3	9.7 ±3.0	0.052
Adductors (MAS)	2.4±0.5	2.1±0.5	0.240
Flexors (MAS)	1.9±0.7	2.0±0.4	0.688
Hamstrings (MAS)	2.2±0.6	2.3±0.6	0.702
Calf Muscle (MAS)	2.5±0.7	2.5±0.5	0.830
Gross Motor Function Measure (GMFM)	103.3±50.9	148.8±59.2	0.174
Gross Motor Function Classification System (GMFCS)	3.3±0.8	3.0±0.9	0.465

MAS: Modified Ashworth Scale.

Table 2. Pre-treatment and post-treatment spasticity values of the Experimental and Control groups and comparison of differences.

	Pre-treatment Mean±SD	Post-treatment Mean±SD	p_1	p_2
Adductors				
Experimental group	2.4±0.5	1.6±0.5	0.005*	0.170
Control group	2.1±0.5	1.6±0.5	0.025*	
Flexors				
Experimental group	1.9±0.7	1.3±0.4	0.014*	0.189
Control group	2.0±0.4	1.7±0.6	0.083	
Hamstrings				
Experimental group	2.2±0.6	2.3±0.6	0.005*	0.060
Control group	2.3±0.6	1.7±0.6	0.014*	
Calf Muscle				
Experimental group	2.5±0.7	1.4±0.5	0.005*	0.195
Control group	2.5±0.5	1.7±0.6	0.005*	

p_1: Pre-treatment – Post-treatment. p_2: Comparison of the difference of two groups. * $p<0.05$.

Table 3. Pre-treatment and post-treatment GMFM and GMFCS results of the groups and the comparison of the differences

	Pre-treatment Mean±SD	Post-treatment Mean±SD	p_1	p_2
Gross Motor Function Measure (GMFM)				
Experimental group	103.3±50.9	149.5±56.06	0.005*	0.002*
Control group	148.8±59.2	164.0±65.5	0.008*	
Gross Motor Function Classification System (GMFCS)				
Experimental group	3.3±0.8	3.1±0.6	0.08	0.004*
Control group	3.0±0.9	3.0±0.9	1.0	

p_1: Pre-treatment – Post-treatment. p_2: Comparison of the difference of two groups. * $p<0.05$.

muscles may have resulted from strong contractions occurring due to lower leg deformities frequently observed in children with CP.[33] Aggressive stretching was required to stretch this muscle group, and functional massage might be insufficient for reducing the severity of spasticity in the long term.

When the pre-treatment and post-treatment findings for the extremities were compared, a statistically significance difference was determined in the hamstring muscles and hip adductors of the experimental and control groups. However, there was more change in the experimental group. The functional massage applied to this group with conventional physiotherapy was effective because the hamstring muscle relaxed more in this group.

When the pre-treatment and post-treatment GMFM scores were compared, a significant increase was achieved in the GMFM scores of the experimental and control groups. However, more difference was observed in the experimental group. Decreasing spasticity leads to verticalization in the child with CP by allowing a larger range of joint motion. Biomechanical improvements occur in the musculoskeletal system thanks to verticalization. The fact that this difference is more in the experimental group is related to the fact that functional massage applied to this group was different compared to the control group, and this provided more decrease in spasticity. Decreasing muscle tone ensures positive improvements in gross motor skills by allowing wider joint movements.[34]

A study conducted in Glasgow University on the mechanical effect of massage on the muscles of diplegic children in the adolescence period revealed that the range of joint motions after the massage was not continuous. However, its application with aggressive stretching provided changes in the shortening sarcomere structure.[35]

On the other hand, in some studies, massage techniques were combined in the treatment of children with CP. In China, a study was conducted on 140 children with CP, and in this study, conventional massage therapies were applied with a combined treatment consisting of western medications. More improvement in terms of social and motor adaptation was observed in children with CP and to whom combined treatment was applied in the post-treatment period.[36]

Massage therapy in children with Cerebral Palsy ensures the prevention of contractures due to stretching, increasing the range of joint motion and flexibility. Massage therapy was defined as a good aid in the entire physiotherapy in addition to conventional physiotherapy and professional rehabilitation.[30,37]

In a study conducted by Maria Hernandez-Reif and Tiffany Field, children with CP were applied 30-minute massage therapy twice a week for 12 weeks.[38] A decrease was observed in spasticity in the children receiving massage therapy, and there were also an increase in the gross and fine motor skills when compared to the other skills, as well as less stiffness in arms. Hernandez–Reif has stated that massage therapy could also be used in physical symptoms related to CP. Moreover, it has been stated that these methods can be used as an auxiliary method in the entire CP rehabilitation.[39]

Finally, the study in which the effects of massage on the mechanical behavior of muscles were investigated revealed that ambulant participants improved their GMFM-66 scores by an average of 6.4%, but the score of the non-ambulant participants was unchanged.[40]

Limitations

Although the children in both groups made significant improvements in their gross motor function and spasticity, this trial did not comprise a no-intervention group. Thus, it is difficult to determine whether the improvements would also have been observed in a group of participants that did not receive any intervention. In addition, this current trial was not carried out with a single or double-blinded study design. Nevertheless, this study is the first to investigate the effects of functional massage on the severity of lower limb spasticity and gross motor function of children with Cerebral Palsy. These effects should be further examined in future studies involving more cases and different variables.

Conclusion

The main purpose of the spasticity treatment was to provide an increase in functions by decreasing the severity of exaggerated muscle tone. Accordingly, this study revealed some important improvements

in spasticity of particular muscle groups in lower extremities applying FM to these muscle groups. It was further revealed that FM might be a safe and effective treatment to reduce spasticity of several muscle groups in conjunction with conventional physical therapy. To our knowledge, a mere aggressive stretching exercise may disturb the children with cerebral palsy and may lead to pain, tendon rupture or an increase in stretch reflex. Massage therapy may be insufficient to reduce the severity of spasticity. At the same time, continuous passive motion can reduce muscle hypertonia and improve lower extremity function in patients with upper motor neuron lesion. For these reasons, instead of applying aggressive stretching exercise to spastic muscle, it may be better to apply stretching exercise with massage therapy simultaneously. Decreased muscle tone might enable to increase the range of motion at joint further and in conjunction with this, it can provide verticalization. Ultimately, development in verticalization might improve motor function. As a result, it has been concluded that the application of FM as a supportive and complementary therapy method with conventional treatments may lead to positive results.

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