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Modified constraint-induced movement therapy in the approach of post-stroke chronic hemiparetic child: a case report

Terapia de constrição e indução ao movimento modificada na abordagem terapêutica de uma criança hemiparética crônica pós-acidente vascular encefálico isquêmico infantil: um relato de caso

Terapia de constricción y inducción al movimiento modificada en el planteamiento terapêutico de un niño hemiparético crónico después de un accidente cerebrovascular isquémico infantil: un reporte de caso

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ABSTRACT | Stroke is the result of disorientation of brain activity of vascular origin, with more than 24 hours. The constrain induction movement therapy (CIMT) is a highlighting method for motor rehabilitation that provides cortical reorganization. The aim of this study was to evaluate the motor function after stroke in a child before and after CIMT. Participated in this study, a female child, nine years old and with chronic left hemiparesis. For the simultaneous analysis of the flexor and extensor muscles of the wrist in maximal voluntary isometric contraction, at the start and the end of CIMT protocol, we used surface electromyography and stabilometry to balance access. The patient had constricted close to the body the non-paretic upper limb, enabling only the use of the paretic upper limb. Still, 14 consecutive sessions of physiotherapy were performed. For constriction, we use a tubular mesh for 23 hours per day. The analysis revealed a root mean square (RMS) increase in flexors and extensors to the wrist, improves balance and weight bearing. Thus, fourteen days CIMT associated a functional activities protocol resulted in an improved of extensors and flexors of the wrist muscle activation pattern and a significant improvement of the balance of the patient.

Keywords | Stroke; Exercise Therapy; Postural Balance; Electromyography.

RESUMO | O acidente vascular encefálico (AVE) é resultado de desorientação da atividade encefálica, de origem vascular, com mais de 24 horas de duração. A terapia de constrição com indução ao movimento (TCIM) destaca-se como método de reabilitação motora que proporciona reorganização cortical. O objetivo deste trabalho foi avaliar a função motora em uma criança pós-AVE, antes e após a TCIM. Participou deste estudo uma criança do sexo feminino, com nove anos e hemiparesia crônica à esquerda. No início e no final do protocolo de TCIM, para a análise simultânea dos músculos flexores e extensores de punho em contração isométrica voluntária máxima, foi utilizada a eletromiografia de superfície para avaliar o equilíbrio a estabilometria. A paciente teve o membro superior (MS) não parético imobilizado junto ao corpo, possibilitando somente a utilização do MS parético. Ainda, foram realizadas 14 sessões consecutivas de fisioterapia. Para a contenção, foi utilizada uma malha tubular, durante 23 horas por dia. A análise revelou um aumento da *root mean square* (RMS) de flexores e extensores de punho, melhora do equilíbrio e descarga de peso após a intervenção. Assim, 14 dias de TCIM associada ao protocolo de atividades funcionais na fisioterapia resultaram em um melhor padrão de ativação muscular dos extensores e flexores do punho e uma importante melhora do equilíbrio da paciente.

Descritores | Acidente Vascular Cerebral; Terapia por Exercício; Equilíbrio Postural; Eletromiografia.

Study conducted at the School Clinic of Physical Therapy of the Universidade Paulista (UNIP) and in the Center For Integrated Rehabilitation, annexed to the State Hospital of Ribeirão Preto (SP), Brazil.
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RESUMEN | El accidente vascular encefálico (AVE) es resultado de la desorientación de la actividad encefálica, de origen vascular, con más de 24 horas de duración. La terapia de constricción con inducción al movimiento (TCIM) se destaca como un método de rehabilitación motora que proporciona la reorganización cortical. El objetivo de este trabajo fue evaluar la función motora de un niño pos-AVE, antes y después de la TCIM. Participó de este estudio un niña de nuevo años y con hemiparesia crónica a la izquierda. Al principio y al final del protocolo de TCIM para el análisis simultáneo de los músculos flexores y extensores de la muñeca en la contracción isométrica voluntaria máxima, se utilizó la electromiografía de superficie para evaluar el equilibrio. El paciente tuvo el miembro superior (MS) no parético inmovilizado junto al cuerpo, lo que permitió sólo el uso del MS parético. Además, fueron realizadas 14 sesiones consecutivas de fisioterapia. Para la contención, se utilizó una malla tubular durante 23 horas al día. El análisis reveló un aumento de la *root mean square* (RMS) de flexores y extensores de la muñeca, mejora del equilibrio y descarga de peso después de la intervención. Por lo tanto, 14 días de TCIM asociada con el protocolo de actividades funcionales en la fisioterapia resultaron un mejor patrón de activación muscular de los extensores y flexores de la muñeca y una mejora significativa del equilibrio de la paciente.

Palabras clave | Accidente Cerebrovascular; Terapia por ejercicio; Equilibrio postural; Electromiografía.

INTRODUCTION

The stroke is defined by the World Health Organization (WHO) as the presence of brain activity dysfunction, of vascular origin, for more than 24 hours[1]. According to its etiology, it may be classified into ischemic (IS) or hemorrhagic stroke (HS)[2-4]. The sudden episodes of ischemia and neurological alterations with symptoms of less than 24 hours are classified as transient ischemic attack (TIA)[5]. Among children, the attacks are scarce; however, due to late diagnosis, usually over 24 hours after birth, serious problems and complications arise[6]. From the epidemiological point of view, in every 100,000 children under 14 years of age, 2 to 8 of them are victims of stroke[6].

Among the sequelae found, there are motor deficits, hemiparesis, decreased strength of the paretic side, muscle tone changes, dyspraxia[7], decreased range of articular joint movement and balance alterations[8]. The difficulty in movement and functionality of the affected limb, especially the hand, is one of the most important sequelae among hemiparetic patients[2,8]. When the non-paretic contralateral limb is functional, plastic mechanisms which include re-learning neuromotor functions, through the enhancement of the sensory and motor cortex, hinder the use of the paretic limb[2,7,8].

Different techniques may be used in rehabilitation[9]; however, among the most recently used ones, there is a especial attention towards the constrain induction movement therapy (CIMT)[10]. Taub, in 1980, presented a therapy which obliged the patient to forcibly use the paretic arm and hand through CIMT[2,4,7-10]. The first studies were carried out in primates, providing evidence for the emergence of the concept of learned disuse and, later on, the understanding of the decreased representation of the cortical area, thus the motor inability of the paretic segment[10]. On the other hand, CIMT promotes reorganization not only on the cortex related to the injury but also on the contralateral one, providing the return of motility and functionality[2,4,7-10]. The CIMT consists of two parts: uninjured upper limb (UL) restraint and intensive training, with oriented and repetitive tasks, through exercises which simulate functional and daily life activities[8-10].

Traditionally, CIMT was developed for the rehabilitation of adult patients, but it is presented as a possibility for the treatment of children with motor sequelae. This possibility was evidenced by works with children who had motor sequelae of cerebral palsy. However, in these works, there is a great variability in movement retention time (from 10 days to 4 weeks), in relation to daily stimulation time (from 3 to 6 hours) and in relation to the stimulation protocol used[11-14].

Due to the scarcity of works using CIMT in children after stroke, and the variability of existing protocols, new works are essential in order to demonstrate its feasibility and efficiency in modifying the motor function of post-stroke children. Thus, the objective of this work was to evaluate the motor function of children, after a stroke, before and after CIMT.

METHODOLOGY

Patient

In order to conduce this work, we selected a female nine-year-old patient, student, with IS sequelae since her birth,

presenting paretic hemibody to the left and difficulties of movement of the left UL. The patient was part of the service of Pediatric Neurological Physical Therapy of the *Universidade Paulista* (UNIP). The case study was approved by the Research Ethics Committee of UNIP (protocol No. 1114/11), where both mother and participant agree to and signed the Informed Consent.

The CIMT protocol was conducted at the School Clinic of UNIP, *campus* Vargas, and the evaluation using surface electromyography (EMG) and stabilometry was held in the Center for Integrated Rehabilitation (CIR) of the State Hospital of the Scholl of Medicine of Ribeirão Preto, *Universidade de São Paulo* (FMRP-USP).

Evaluation procedures

For the electromyographic collection, we used the EMG System do Brasil (São José dos Campos, São Paulo), model EMG 410C, with two channels, using A disposable and double adhesive bipolar electrodes (with a established interelectrode distance), model (AGCL), by Hal. In order to perform the collection, the hair in the area the electrodes would be placed were shaved off with a disposable razor device. The skin of the patient was abrased, using a nail file, for the removal of dead cells, and the area was then wiped off with alcohol at 70%[15,16].

The active electrodes were placed in the muscle belly, parallel to the fibers and close to the motor points of the flexor and extensor muscles of the wrist. The dispersive electrode was fixed in the styloid process of the ulna[17]. All preparatory procedures and the placing of the electrodes were carried out according to the recommendations of the project by the European Union on Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM)[15,16].

For the analysis, the patient remained in a sitting position, with elbow flexion at 90º. During the collection of the electromyographic signal, the patient would support, with her wrist in neutral position (either pronated or supinated), a foam roller, a 1kg weight and another 2 kg weight, making the analysis of the signal to happen simultaneously for both wrist extensors and flexors.

Stabilometry was carried out for the assessment of the balance, analyzing the oscillations in the center of pressure on both the anteroposterior and mediolateral axes. For the assessment, the force platform EMG System do Brasil (São José dos Campos, São Paulo) was used; the analysis of the data was performed by the Biomec 4000 software. The assessment was carried out in bipedal mode, with eyes opened and closed during 30 seconds.

Intervention procedures (CIMT protocol and physical therapy)

The patient had the non-paretic UL placed under constriction, using a tubular mesh that would keep the right UL positioned in abduction and internal rotation of the shoulder and elbow flexion at 90º, 23 hours a day, for an overall period of 14 days (Figure 1). The constraint was removed only during physical therapy sessions, which happened seven days a week, for the performing of functional activities, such as: coordination exercises and stimulation for clamping and pressure movements, sensorimotor stimulation, stretching of the right and left ULs.

This way, after physical therapy sessions, the tubular mesh would be replaced and the patient would be obliged to perform her daily functional activities with the paretic limb. During the protocol, the patient attended to 14 straight days of physical therapy sessions.

Before the interventions, the patient was submitted to the EMG analysis and to the stabilometry; after this procedure, she was placed a constriction on the non-paretic UL. After the 14 days of constriction, with a daily physical therapy session, the protocol was ended and again the EMG analysis and stabilometry were conducted. Each physical therapy session lasted 50 minutes. The functional activities performed daily composing the treatment were: getting dressed: buttoning and unbuttoning, opening and closing the zipper, passing the shoelace, tying and untying it; personal hygiene: combing and tying up the hair, brushing her

Figure 1. Position of the non-paretic upper limb with the tubular mesh

teeth; feeding: taking a glass to her mouth, taking a tableware to her mouth; house chores: hanging clothes with the clothespin on the clothesline; manipulating objects: opening and closing locks, opening and closing door handles of different thickness, fitting match toys, activities with clamping and holding objects.

Statistical analysis

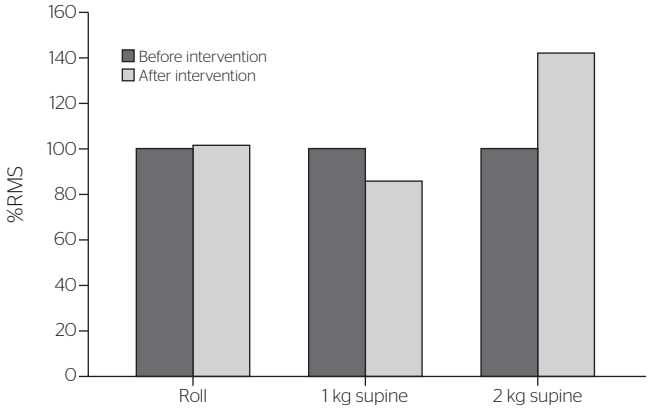
The results of the initial (before the protocol) and final (at the end of the protocol) assessment were descriptively compared, and the EMG results were normalized in percentage. For the EMG, it was compared the level of activity of the RMS signal of the flexor and extensor wrist muscles. The stabilometry of the assessment was performed before the beginning of the CIMT protocol, immediately after the constriction, at the fourteenth Day (the end of the protocol), the UL still constricted, and right after the removal of the constriction. The assessment compared the oscillation in the anteroposterior and mediolateral pressure centers.

RESULTS

After the end of the CIMT protocol, the evaluation of the wrist flexor muscles showed higher RMS activation, when compared to the values obtained before the beginning of the treatment. For the activity of holding the foam roller there was a 1.37% increase of the RMS activity, when compared to the initial assessment. In the neutral wrist position and in supine position sustaining an weight of 1 kg, it was observed a reduction of RMS activity in 14.27%. For the neutral and supine wrist position, holding a weight of 2 kg, it was observed an increase of 41.87% of the RMS activity (Figure 2).

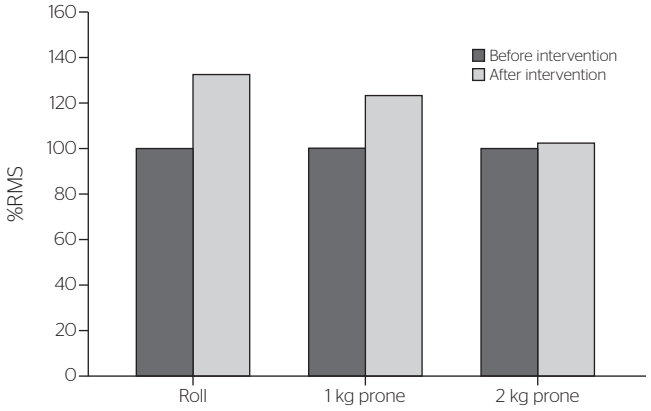
In the same direction, the analysis of the wrist extensor muscles was observed higher RMS activation. In the position of holding the foam roll, RMS activation was 33.3% higher than in the beginning. For the wrist neutral and prone position holding weights of 1 and 2 kg, it was observed a increase of RMS activation by 24.27 and 2.41%, respectively (Figure 3).

As for the results obtained by stabilometry, in the initial evaluation, before the CIMT protocol, the patient presented a gravitational center with posterior displacement to the left, -0.53 and -1.14, respectively. Immediately after the constriction of the non-paretic UL, we observed an increase in posterior displacement and a decrease in the displacement to the left, 1.27 and -0.04, respectively. After 14 days, at the end of the protocol, still with the member under constriction, the lateral deviation was now to the right and the displacement, which was previously posterior, changed into an anterior position, 0.05 and 2.19, respectively. Immediately after the removal of the constriction, the lateral deviation to the right diminished, getting close to the medium position, and the anterior displacement increased, 0.18 and 0.58, respectively (Figures 4 and 5).



RMS: root mean square

Figure 2. Figure representing the root mean square activity of the flexor muscles of the wrist in the activities of holding a roll, a 1 kg weight and a 2 kg weight in a supine position; the values indicate the root mean square percentage obtained at the beginning and at the end of the protocol for constriction therapy with movement induction



RMS: root mean square

Figure 3. Graphic representing the root mean square activity of the extensor muscles of the wrist in the activities of holding a roll, a 1 kg weight and a 2 kg weight in prone position; the values indicate the root mean square percentage obtained at the beginning and at the end of the protocol for constriction therapy with movement induction

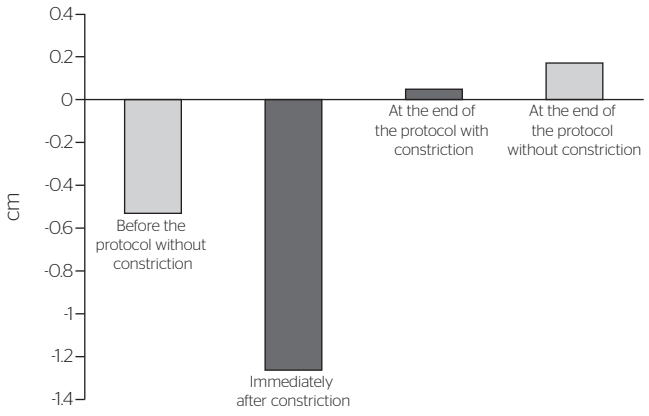


Figure 4. Graphic representing the anteroposterior displacement of the patient in the force platform; negative values indicate posterior displacement, and positive ones, anterior displacement

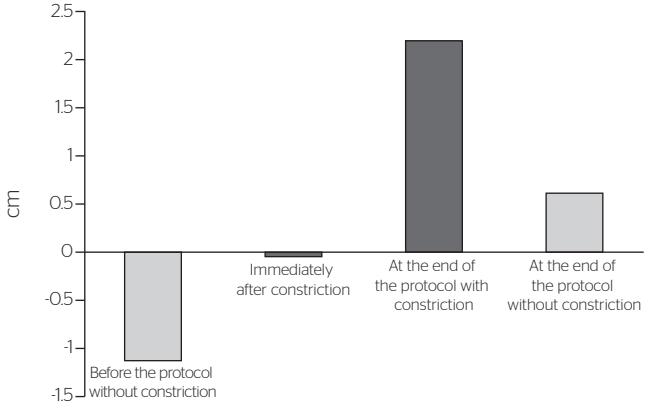


Figure 5. Graphic representing the mediolateral displacement of the patient in the force platform; negative values indicate displacement to the left, and positive ones, displacement to the right

DISCUSSION

The present study shows that the CIMT may modify RMS activity of the paretic UL, as well as the balance, of a patient with left hemiparesis due to IS. Some authors showed that the contention of the non-paretic limb and the forced use of the paretic one for daily activities have a direct effect on motor re-learning[2,4,8-10]. This occurs because, after the brain injury, the affected cortical area presents a decrease in its representation, producing errors in motor performance and enabling the rise of learned nonuse[2,4,8-10].

The CIMT, through the forced used of the limb and the protocol of functional activities, with repetitive movements by the paretic limb, increase the affected cortical area representation, providing better motor performance, optimizing learning and reversing the learned nonuse[8,9,19]. The data available in literature show the benefits of CIMT in patients of several age ranges[8,20], including children[21]. These results corroborate what was observed in this study, which used an original and distinct protocol from the ones used in the previously mentioned studies. However, it is important that this protocol is tested in a group of patients, once that, in this specific study, the results concern only one patient.

Surface electromyography is a tool used in order to evaluate muscle activation in patients after a stroke[22,23]. In this sense, the rehabilitation works with patients after a stroke, considered an increase in RMS activity, in tibial anterior and spine erector muscles, as an evolution pattern on muscle development. Thus, a higher RMS activation may represent higher muscle request and evidence, then, greater motor control[24,25]. In this work, the extensor RMS activation increased, preceded by a decrease in RMS activation of the flexor muscle group, which is a direct evidence related to the patterns of reciprocate medullar inhibition[24,25].

A recent study o four group showed that the CIMT, a specific therapy for the improvement of motor performance of paretic UL, may also change the balance center of patients with chronic hemiparesis[26]. By the use of force platform, the changes in the patient's balanced were revealed[27,28]. Possibly, the methodology of constraining the non-paretic upper limb to the body, using a tubular mesh instead of gloves, is the difference responsible for these results[29-32], once that in the previous study the same methodology was used, producing results as for the gravitational center of patients[26].

Hemiparetic adult patients usually divert their balance center towards the non-paretic lower limb (LL)[28]. The patient of this case report did not present this pattern, once a discrepancy of 1 cm on the left LL kept her diverted to the back and to the left. Even though, the non-paretic UL constriction was able to change this pattern, correcting her balance to an anterior position, which, by the biomechanical point of view, may facilitate the gait[33].

For the patient, the CIMT protocol used in this study produced motor acquisitions to the paretic UL right after the first week, contributing to her adherence to the treatment, once that CIMT may be frustrating, by making the patient face, in a very intense way, their motor impairment[9]. It is important that new works are carried out with groups of patients. Still, shorter constriction periods need to be tested, once they may be effective and provide a treatment best tolerated by different kinds of patients with motor impairments of higher or lower impact on their daily activities.

CONCLUSION

EMG and stabilometry were appropriate tools in the assessment of the motor function of the patient before the beginning of the treatment, evidencing that the CIMT protocol used in this study was efficient in modifying the motor function of a child after a stroke.

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