Fisioter Bras 2017;18(4):449-56

ARTIGO ORIGINAL

Constraint-induced movement therapy in the rehabilitation of chronic hemiparetic patients in the Amazonia

Terapia de restrição e indução do movimento na reabilitação de pacientes hemiparéticos crônicos na Amazônia

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Recebido em 3 de novembro de 2016; aceito em 26 de maio de 2017.
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Abstract

Introduction: The stroke is one of the incident diseases in the world, causing numerous changes to the functionality especially those related to upper limb functions. *Objective*: To evaluate the influence of modified Constraint-Induced Movement Therapy (mCIMT) on functional recovery, range of motion (ROM) and muscle tone of chronic hemiparetic upper limb (UL). *Methods*: Seven subjects (52.75 ± 6.63 years old) were evaluated before, straightaway and one month after 12 sessions of mCIMT, by goniometry, modified Fugl-Meyer Assessment (mFMA) and modified Ashworth Scale (MAS). *Results*: Functionality improved 74.7% after treatment and 79.5% one month after the end of treatment. There was improvement in passive motion ($p = 0.01$), in pain ($p = 0.004$) and UL motor function ($p \leq 0.001$), increased range of flexion, extension, abduction and adduction of the shoulder and flexion and radial deviation of the wrist ($p = 0.05$) and muscle tone reduction ($p < 0.05$). *Conclusion*: mCIMT was effective for recovery of ROM in shoulder and wrist; recovery of the paretic UL functionality and spasticity reduction, and the results remained after the end of treatment.
Key-words: stroke, physical therapy, rehabilitation, human movement, modified constraint-induced movement therapy.

Resumo

Introdução: O AVE é uma das doenças mais incidentes no mundo, provocando inúmeras alterações para a funcionalidade, principalmente relacionadas às funções do membro superior. *Objetivos*: Avaliar a influência da Terapia de Restrição e Indução do Movimento (TRIM) na recuperação da funcionalidade, amplitude de movimento (ADM) e tônus do membro superior (MS) de pacientes hemiparéticos crônicos. *Material e métodos*: Sete voluntários (52,75 ± 6,63 anos) foram avaliados antes, imediatamente após e um mês após 12 sessões de TRIM, pela goniometria, *Modified Fugl-Meyer Assessment* e *Modified Ashworth Scale*. *Resultados*: A funcionalidade melhorou 74,7% após intervenção e 79,5% um mês após o término do tratamento. Houve melhora da movimentação passiva ($p = 0,01$), da dor ($p = 0,004$) e da função motora do MS ($p \leq 0,001$); aumento da ADM de flexão, extensão, abdução e adução do ombro e flexão e desvio radial do punho ($p < 0,05$) e redução do tônus muscular ($p < 0,05$). *Conclusão*: A TRIM foi eficaz para recuperação da ADM do ombro e punho; retorno da funcionalidade do MS parético e redução da espasticidade, tendo os resultados se mantido após o término do tratamento.
Palavras-chave: acidente vascular encefálico, fisioterapia, reabilitação, movimento humano, terapia de restrição e indução do movimento.

Introduction

In Brazil, the stroke has been considered an impacting condition on public health due to disabilities and/or functional limitations, standing between first and third leading cause of morbidity or mortality [1]. Eighty percent of strokes are caused by cerebral ischemia and twenty percent by intracerebral or subarachnoid hemorrhage [2].

The stroke is described as an event in which there is an interruption of the cerebral blood flow, which causes damages in the neurological function, what are manifested in long term incapacities and an average survival around 1 to 8 years [1].

The major neurological dysfunctions after a stroke are hemiparesis as well as sensory disorders, which are usually found in the acute phase in the trunk, upper and lower limbs. However, due to the need of use of the lower limbs to the gait, the prognosis is better when the brain injury compromises areas related to the upper limbs, both motor and sensory level.

On the other hand, considering the functional importance of the upper limb to the activities of daily living (ADLs), it is imperative to explore treatment strategies for functional recovery of the paretic upper limb [3]. In addition, epidemiological data indicate that more than 85% of those affected are deficient in the upper limbs and that of this total, only 25 to 35% reach functional recovery [3].

In order to achieve an efficient recovery of function, one of the physical therapy strategies is the stimulation of neural plasticity through physical exercise, as evidenced by the use of modified Constraint-Induced Movement Therapy (mCIMT), which encourages the use of the paretic upper limb with the purpose of minimizing the functional deficits from multiple brain damages [4].

In this context, the best time to start the rehabilitation is the early phase of the disease, which corresponds to the first three months after injury, so as to the functional improvement is more evident at this time and the recovered motor function may persist due to neural plasticity. Nevertheless, it is known that in the chronic phase of stroke (six months after) neurological damages are identified more accurately, since there are compensatory movements and incorrect relearning or not acquiring of functions, impairing the functionality [5]. In addition, animal studies have shown that an overload of stimuli on the paretic limb, as occurs during treatment using mCIMT, in early stages after injury (up to 3 months), may be detrimental to recovery, as it may stimulate the mechanism of excitotoxicity, widening the area of the lesion [6]. In this way, therapeutic care in the early phase after injury is fundamental, so that the paretic limb presents ideal conditions to respond efficiently to the stimuli applied with the use of mCIMT in the chronic phase.

The limitation or lack of functionality on the paretic side might be related to the difficulty of moving the affected limb, encouraging the use of unaffected limb, in a compensatory way, inducing the development of a behavior called "learned non-use" [7], which further increases the motor disability [8].

Studies showed that CIMT promotes the increased use of the affected UL due to the healthy limb restriction, stimulating the relearning by overcoming "learned non-use" and inducing a cortical reorganization, through the repetitive and sustained training, which reverses the loss of the limb cortical representation, caused by non-use [8,9].

Thus, mCIMT has been a potential method of sensorimotor gains after a stroke being considered more effective than traditional therapies to promote changes in the representation of an impaired upper limb in the cerebral cortex [10].

The aim of this study was to evaluate the influence of modified Constraint-Induced Movement Therapy (mCIMT) on functional recovery, range of motion (ROM) and muscle tone of chronic hemiparetic upper limb (UL).

Methods

The study was approved by the Ethics Committee of the Public State Clinic Hospital Gaspar Viana Foundation (Registration Number 057/11), and carried out in the Physiotherapy School Clinic, after signing a consent and information form by the subjects.

It was considered as inclusion criteria: presenting chronic hemiparesis after a stroke; ages between 50 and 60; ability to actively perform the wrist flexion movement, metacarpophalangeal and interphalangeal active extension of 10° and wrist extension of 20°; absence of cognitive impairment. The exclusion criteria were: presenting progressive degenerative disease; stroke recurrence; deformities and installed and irreversible compensation of the UL; hemiplegic pattern of the UL; visual and hearing impairment that prevented the understanding of verbal commands or seeing the task to be performed.

Ten subjects were recruited; three did not complete treatment due to absence in therapy sessions and stroke recurrence, remaining seven volunteers for the study.

Evaluation procedures

Modified Fugl-Meyer Motor Assessment

The Modified Fugl-Meyer Assessment (MFMA) is used to evaluate the motor function of the paretic upper limb [11], considering 7 aspects: Passive movement and pain; Sensitivity; Upper limb motor function; Coordination / Upper limb velocity; Motor function of lower limb; Coordination / Lower limb velocity and Balance. Each item is punctuated as follows: 0 = cannot be performed; 1 = partially performed and 2 = fully performed, totaling 100 points for normal motor function, 66 being the maximum for the upper limb and 34 for the lower limb. It should be emphasized that in this study only the section for upper limbs of the scale was selected.

Modified Ashworth Scale

The Modified Ashworth Scale (MAS) enables the assessment of muscle tone in individuals affected by stroke, in order to quantify the degree of the spasticity. Thus the scale is graduated from 0 to 5, where 0 = no increase in muscle tone; 1 = slight increase in muscle tone, which is manifested by sudden motion or a minimum resistance at the end of the motion, when the segment is moved in flexion or extension; 2 = small increase in muscle tone, manifested by sudden motion followed by minimal resistance throughout the range of motion; 3 = more marked increase in muscle tone throughout most of the range of motion but the joint is still displaceable; 4 = considerable increase in muscle tone with difficulty in passive motion; 5 = affected segment is rigid in flexion or extension [12]. In this study, the scale was used to assess the tone of the flexor muscle group of the MS.

Goniometry

The ROM was measured in the affected upper limb using manual goniometer (Carci®) for flexion, extension, adduction, abduction, medial and lateral rotation of the shoulder; flexion and extension of the elbow; forearm pronation and supination and flexion, extension, ulnar deviation and radial wrist.

All evaluations were performed before the physical therapy intervention, after its end (corresponding to the last day of intervention) and 30 days after the last intervention session, representing a one-month follow-up.

Intervention procedure

The treatment consisted of applying a modified CIMT protocol three times a week on alternate days, lasting two hours each session, for a period of four weeks, totaling 12 sessions. The healthy forearm, wrist and hand were kept in a neutral position by a splint made for each volunteer. The subjects remained in sitting position to perform activities with the paretic UL. The material used to stimulate the paretic limb remained on a table, where also the healthy UL was supported. The examiner stood opposite the paretic limb, guiding volunteers to perform the exercises on the ADL board to fit keys, open different locks, sew on a sewing table, hit a nail.

Thus, in each intervention session, the subjects performed functional tasks individually, in the following order of execution: grabbing a glass and bring it to his mouth, grabbing a spoon and taking it up his mouth, combing hair with a hairbrush, performing activities with assembly games, using the ADL board, taking a piece of bread or cracker from the plate and taking it up his mouth and eating it, cleaning the plate and the table with a sponge, bouncing the ball on the floor, playing the game "Escravos de Jo" (a traditional Brazilian game which the players have to sing the song while passing a representative object to the next players on a circle), passing a sheet of paper between examiners and, finally, greeting them with handshake. These tasks were repeated throughout the treatment period.

Data analyses

The normality Shapiro-Wilk test was applied to all variables. For variance analysis and the MFMA and MAS we used the two-way ANOVA test, followed by the t test; for immediate and delayed pre and post intervention comparisons and analysis of the goniometer variables among the 14 studied movements, the Friedman test was applied to compare the three time points of evaluation. The data was processed in BioEstat software version 5.2.

Results

The volunteers characteristics are described in Table I, which demonstrates the characterization of the sample regarding age, chronicity of the lesion, gender and affected body side. In this way, we observed that the sample shows a larger number of men, with age group permeating aging, being more affected in the right side of body, and with a considerable lesion time of 18 ± 3.4 months.

The most significant finding of this study in relation to the ROM refers to the flexion, extension, abduction and adduction of the shoulder, which showed significant improvement after the intervention, which was maintained during follow-up. However, the shoulder rotation movement showed no improvement in ROM ($p > 0.05$) and the same occurred with other regions analyzed, as shown in Table II.

In General MFMA score and its variables, there was an increase in average passive motion, pain and upper limb motor function after immediate and delayed treatment when compared to pre-treatment ($p = 0.05$), already in the indicators of sensitivity and coordination / speed, the differences were not significant, as shown in Table III.

Table IV shows the behavior of muscle tone of the flexor muscle group evaluated by the MAS in the three moments, where progressive reduction of the muscle tone of the paretic upper limb ($p < 0.05$) was observed.

Table I - *Characterization of the sample*.

Age	52,75 ± 6,63 years old	
Average time of injury	18 ± 3,4 months	
Gender	Male = 5 (62,5%)	Female = 2 (37,5%)
Side of hemiparesis	Right = 6 (75%)	Left = 1 (25%)

Table II - *Mean values and standard deviation of the degree of motion of the shoulder joints, elbow and wrist and forearm compared at three time points.*

Articulations	Movements	Pre-treatment	Post-treatment	Post-treatment late
Shoulder	Flexion	123° ± 54,35	134,28° ± 55,33*	134,28° ± 55,33*
	Extension	29,57° ± 12,83	38,42° ± 8,20*	40,71° ± 7,31*
	Abduction	118° ± 53,22	130° ± 54,08*	131,42° ± 55,43*
	Adduction	26,14° ± 13,59	35° ± 8,66*	36,42° ± 6,26*
	Medial rotation	59,71° ± 41,74	61,42° ± 42,59	61,42° ± 42,59
	Lateral rotation	49,42° ± 34,48	51,42° ± 36,70	57,14° ± 40,70
Elbow	Flexion	134,28° ± 15,39	141,42° ± 6,26	144,28° ± 1,88
	Extension	5,14° ± 8,95	2,14° ± 5,66	1,42° ± 3,77
Forearm	Pronation	85° ± 11,18	87,14° ± 7,55	87,14° ± 7,55
	Supination	70° ± 25,81	75° ± 19,57	77,14° ± 17,04
Fist	Flexion	51,85° ± 13,38	55,57° ± 17	70° ± 24,66*+
	Extension	54,14° ± 19,75	59° ± 15,17	59,28° ± 15,39
	Ulnar deviation	27,85° ± 18,89	31,71° ± 17,19	32,14° ± 16,79
	Radial deviation	13,14° ± 8,61	14,71° ± 6,75	14,71° ± 6,75

Table III - *Mean values and standard deviation of the paretic upper limb functionality in the three time points*.

Description variable Mfma	Pre-treatment	Post-treatment	Post-treatment late
Passive movement and pain	13,14 ± 8,47	17,71 ± 7,45*	18,57 ± 7,39*
Sensibility	11,71 ± 0,75	12 ± 0	12 ± 0
FM–MS	40,57 ± 18,34	46,14 ± 16,80*	46,85 ± 15,46*
Coordination/Speed	4,42 ± 1,13	4,85 ± 1,06	5 ± 1,15
General score	68,14 ± 25,41	74,71 ± 24,68*	79,57 ± 24,81*

Table IV - *Mean values and standard deviation of muscle tone in the paretic limb in all three time points, as assessed by the Modified Ashworth Scale (MAS).*

Variable Description	Pre-treatment	Post-treatment	Post-treatment late
MAS	2,42 ± 0,53	1,428 ± 0,53*	1,142 ± 0,37*

Discussion

Although this study presents a reduced sample size, it does not differ from other studies using mCIMT, since most are characterized as “case study” [5,13]. However, there is a general agreement that CIMT enables increase in dexterity and grip strength, improvement in functional independence, reduced average time to perform motor tasks [13,14]. However, few studies have reported effects on a wider sample [15,16] and when the method is applied in the chronic phase [10,17] and it is evaluated not only the functionality but also the range of joint motion and the tonus behavior in response to the intervention, being this the focus of this present study.

From the post-stroke pathophysiological changes, it is possible to elucidate the effects of mCIMT, since after stroke, a spontaneous cortical reorganization occurs, which reaches its *plateau* after 3 months and reflects the neurotransmission recovery in the spared tissue near or far from the site of injury [18,19]. From appropriate intervention begins a recovery induced by training, which is not limited by time, and occurs by synaptic and cytoarquitectural changes and by neurogenesis and can be observed late and it depends on individual experience and rehabilitation [20].

This way, the cortical reorganization includes increasing of dendrites, synapses and neurotrophic factors, which are essential for the survival of nerve cells, characterizing the plasticity of the nervous system. In this process, after the motor cortex injury, motor homologous regions of the unaffected hemisphere or the intact cortex adjacent to the injury bear the lost function. Because of cortical reorganization, which can start from one to two days after stroke and lasts for months, it is possible to recover, at least in part, the skills, which had been lost [21].

Although a direct measure of plasticity was not performed in this study to demonstrate the effects of mCIMT on a possible cortical reorganization, indirect measures (ROM, motor function and muscle tone) showed the reflex of the plastic alterations induced by the mCIMT.

The results of this study regarding the paretic shoulder range of motion and radial deviation of the wrist, which were maintained 30 days after the end of treatment, suggest that the re-learned movements were incorporated into the volunteers daily life activities, reaffirming the efficacy of the intervention and its role in a possible cortical reorganization, since the mCIMT is characterized as intensive and incorporates repetitive activities and progressive difficulty, being proven its effects in the short and long term [22].

Modified CIMT is known to stimulate neuroplasticity, as it promotes increased cortical excitability, metabolic rate and blood flow in the brain, allowing an increase in the sensory and motor areas of cortical representation, both contralateral and ipsilateral to the affected upper limb, as well as bilaterally in the hippocampus, contributing to the functional recovery of the affected limb [23].

It is important to highlight that mCIMT shows effectiveness in motor recovery from months to years after the injury [24], therefore contemplating the rehabilitation needs of the subjects in this study.

In the context of chronicity, it is known that after stroke the tendon and muscular resistance to speed-dependent stretching is remarkable, which characterizes the upper motor neuron injury [25,26]. Despite the spasticity impacts after a stroke are still questionable, although the treatments for abnormal tone control show good results, they did not correlate with the improvement in functionality [27]. There is no doubt that the control of spasticity facilitates increasing ROM opposing to postural pattern shown in hemiparesis, since the muscles committed are properly stimulated, as it occurs during mCIMT treatment. Thus, we consider that the increase in ROM and improvement in muscle tone control observed in this study are intrinsically associated.

Thus, the control of spasticity in this study seems to have resulted from inherent factors to the method of intervention chosen and the protocol executed, since the proposed activities stimulated motion of the extensor muscles of the UL and abductors in order to inhibit the predominant flexor and adductor pattern. With repetitive and intense stimulation during application of mCIMT, there was an activation of the physiological mechanism of reciprocal inhibition, compromised by injury. As the proposed tasks were antagonistic to the postural pattern shown by the UL, it is considered that the reciprocal inhibition process has been activated, facilitating the inhibition of abnormal muscle tone and also the functional recovery [28-30].

Considering the results found in this study, both the ROM and control of muscle tone contributed to the improvement of functionality. In this study, the overall score of MFMA showed clear recovery immediately after the intervention, which was held 30 days after its completion.

Improved functionality in this study from the application of MFMA scale was 74.1% in the post-treatment immediately and 79.5% in the late post-treatment compared to pre-treatment values. This improvement can be attributed to the intense repetition of functional activities. According to Souza *et al.* [31], they stimulate motor learning, providing better handling of the objects.

Cortical reorganization in patients with chronic stroke who underwent mCIMT has been reported by Cruz, Santana and Dumas [7], which related neuroimaging with functional improvement and reaffirmed the possibility of learning and motor cortical reorganization even when the intervention is applied in the chronic phase. They justify that intensive motor training promotes brain development, possibly leading to the recruitment of a large number of neurons adjacent to the injury to the innervation of the UL paretic muscles, inducing neuronal plasticity, which can generate neuroplasmatic modeling in motor areas.

In this study, even if there has not been performed neuroimaging, the results of ROM, muscle tone and functional recovery suggest the presence of cortical reorganization when using mCIMT later after the injury.

Conclusion

The mCIMT protocol used in this study was effective for the improvement of the range of motion, stabilization of the muscle tone and recovery of the functionality of the upper limb of chronic hemiparetic patients after stroke, and the results were maintained until one month after the intervention, possibly by the incorporation of the motor tasks re-learned to the activities of daily life.

However, there is a need for studies with a greater number of volunteers with this profile in the region, and that can be followed up in longer or even evaluated interventions in a longer posttreatment period.

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