Qualitative analysis of the effect of constraint induced movement therapy in children with cerebral palsy

CASE REPORT

Análise qualitativa do efeito da terapia por contensão induzida em crianças com paralisia cerebral

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ABSTRACT: This study describes the results of four children with hemiparetic cerebral palsy, age between four and eleven years (6.50± 3.32) who had performed a Constraint-induced Movement Therapy (CIMT) protocol. The purpose was to analyze qualitatively the effects of the CIMT protocol on the use of the affected upper limb. The protocol was performed for three weeks, with restriction of the non-affecte upper limb and functional activities were performed with the transfer of gains during treatment to the real environment. A qualitative analysis of the upper limb movement was performed through the Quality of Upper Skills Test (QUEST) scale and the assessment of distal adjustments. Improvements on the QUEST scale score and on the distal adjustments were observed in all four participants after the training protocol. The constraint-induced movement therapy may be an effective intervention aiming to improve the quality of the upper limb movement in children with hemiparetic cerebral palsy.

KEYWORDS: Physical therapy modalities; Cerebral palsy; Child; Child preschool.

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RESUMO: Este estudo descreve quatro casos de pacientes com paralisia cerebral hemiparética, com idade entre quatro e onze anos (6,50± 3,32), que realizaram um protocolo de Terapia por Contensão Induzida (TCI). O objetivo foi analisar qualitativamente o efeito da TCI no uso do membro superior acometido. O protocolo foi realizado durante três semanas, onde o membro não acometido foi contido por gesso sintético e foram realizadas atividades funcionais com a transferência dos ganhos ocorridos durante o tratamento para o ambiente real. A análise qualitativa foi realizada por meio dos ajustes distais do membro acometido e por meio da escala *Quality of Upper Skills Test (QUEST*). Os quatro participantes obtiveram melhora nos ajustes distais e na pontuação da escala aplicada. A terapia por contensão induzida pode ser uma estratégia de intervenção eficaz para crianças com paralisia cerebral hemiparética.

DESCRITORES: Modalidades de fisioterapia; Paralisia cerebral; Criança; Pré-escolar.

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INTRODUCTION

Motor impairment is one of the main characteristics of children with cerebral palsy (CP), which influences their functional performance[1]. Occurring in about 29% of the cases of CP, the spastic hemiparesis[2], compromises a hemi body, with limitations generally more pronounced in the upper limbs[3].

Children with hemiparetic CP often present limitations in the ability to reach, hold, and manipulate objects[4]. The sensory deficit, spasticity and muscle weakness of the affected upper limb can serve as barriers to exploration, self-care and to perform activities of daily living[5]. Due to motor difficulties with the most affected upper limb, individuals begin to neglect this limb, and start to perform his motor tasks with the unaffected limb, characterizing a phenomenon described as learned non-use[6]. The learned non-use is describe by the reduced use of the affected arm in activities of daily living, and is considered a behavioral alteration in consequence to the difficulty to execute movements with the affected arm, and impact the quality and frequency of the movements performed with this arm[7].

In this sense, rehabilitation strategies have a fundamental role to avoid these limitations in patients with CP. Among the available interventions, the constraint-induced movement therapy (CIMT) has shown to have good benefits. This intervention was developed in 1980 by Edward Taub, initially for patients with upper limb motor impairments due to stroke[8].

CIMT studies have shown positive results regarding hand and upper limb function in children with CP[4,9,10,11]. However, it is still necessary the exploration of the CIMT effects on the quality of the movement on different ages during time.

In order to add knowledge regarding to the pediatric rehabilitation field and collaborate with scientific evidence based on interventions to improve social participation and quality of life of children with CP, the present study aimed to analyze the effects of a CIMT protocol by analyzing the qualitative changes on distal adjustments and use of the affected upper limb and in children diagnosed with hemiparetic cerebral palsy.

We hypothesize that after the CIMT protocol, improvements on the quality of movement and functionality of the hemiparetic upper limb would occur and that these effects may be maintained over time after the protocol.

METHODOLOGY

The study was approved by the Human Research Ethics Committee of the Federal University of São Carlos, protocol number 1.171.889, and was finished in 2017.

Participated on this study four children diagnosed with spastic hemiparetic cerebral palsy, age between 4 and 11 years old (6.50±3.32), being three boys and one girl, presenting asymmetric use of the upper limbs. All participants were from the School Health Unit (USE), from the Federal University of São Carlos (UFSCar), Brazil.

Parents or guardians of children with CP were contacted by phone and informed of the study's objectives and procedures. Those who accepted to participate in this study were instructed to assigned a Consent Form, which is in accordance with the Declaration of Helsinki and with the resolution number 466/2012 of the Brazilian National Health Council.

All participants were classified according to the Gross Motor Function Classification System (GMFCS) and the Manual Skills Classification System (MACS) (Table 1), and met the criteria required to perform the CIMT training protocol, as established in the literature[12].

Table 1 – Characterization of subjects according to age, weight, height, GMFCS and MACS of the chidren that were selected for the study

Participant	Sex	Age (years)	Weight kg)	Height (m)	GMFCS	MACS
1	M	4	21.00	1.06	I	III
2	M	7	23.20	1.16	II	III
3	F	4	13.30	1.00	I	III
4	M	11	40.8	1.42	II	III
	Means	**6,50**	**24,57**	**1,16**	_____	_____
	SD	**3,32**	**11,62**	**0,18**		

SD= standard deviation

Assessment procedures

The pre and post training assessments took place at the Movement Research and Analysis Laboratory (LaPAM), part of the Neuropediatrics and Motricity Study Center (NENEM), from the Physiotherapy Department of the Federal University of São Carlos (UFSCar-Brazil).

The pre-assessment occurs between seven days before the beginning of the CIMT protocol. After the end of the protocol the post-assessment were performed, being: 24 hours 10 days 2 months after the end of the training. All the assessments and the CIMT protocol were carried out by a physical therapists with experience in pediatric rehabilitation.

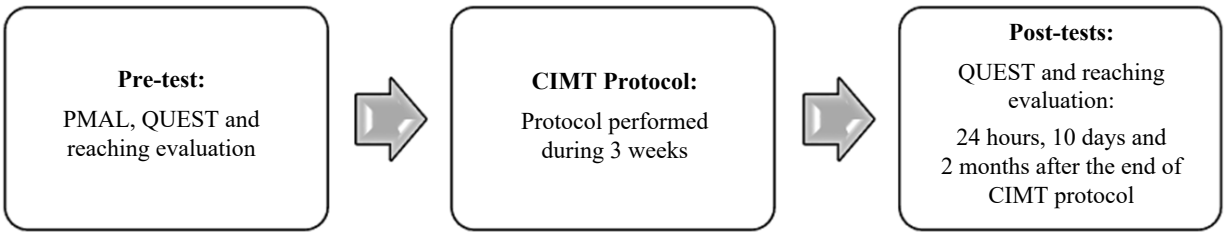

Figure 1 – Experimental Protocol

Quality of Upper Extremity Skills Test (QUEST)

The scale Quality of Upper Extremity Skills Test (QUEST) was performed in all assessments. This scale evaluates the quality of movement of the upper limbs in children with CP in four domains: dissociated movements (1), grasp (2), protective extension (3) and weight bearing (4). Quality of the hand function is defined based on the score obtained in each domain, and the total score is the result of the sum of all domain scores divided by the number of tested domains performed, being highest scores showing better quality of the upper limb use[13]. On this study we assessed the abilities related to the domains 1, 2 and 3.

Qualitative analysis of the reach-to-grasp ability

To assess the reach-to-grasp ability participants sited in a chair in front of a table with a cup on the top. The reach-to-grasp task was performed with the hand coming out of the table, grasping the cup, bringing it to the mouth, and putting it back on the table. The task performance was video recorded by three cameras positioned one anterior, and two laterally to the participant. Each participant made a training trial and then three trials were made with the most motor affected upper limb.

The upper limb performance during the reach-to-grasp task were used to evaluate the distal adjustments of the hand, which involve the adjustments made by the hands and fingers at the end of the reaching movement. In this study, the distal adjustments considered were: *palm orientation*, that corresponds to the position of the palm of the hand when it touches the object, and can be classified as horizontal, oblique or vertical[14]; *surface of contact of the hand and fingers*, which evaluates the surface of the hand and fingers that touch the object at the moment of reaching, being classified as ventral or dorsal[15]; *hand opening at the moment of touch*, which comprises the position of the hand and fingers at the moment of reaching, and can be classified as open, semi-open or closed hand[16], and *grasping*, which will be considered when the participant grasps the object without dropping it immediately[17]. Classified in grasp with help of the unaffected limb and grasp with no help.

CIMT Protocol

After the first assessment, a synthetic cast was made to each participant to restrain the use of the unaffected limb (most used arm). The CIMT protocol was conducted at each participant's house. During the protocol period, the unaffected limb was restrained during 24 hours per day, being removed only during therapy time to clean the arm. The protocol occur during three consecutive weeks, with intensive training for five consecutive days a week, for three hours per day.

The Pediatric Upper Extremity Motor Activity Log (PMAL) scale was applied only in the pre-assessment to verify the most compromised activities and to determine the activities to be performed during the protocol and the activities of the task diary that should be performed by the participant beyond the training time, and checked by the parents on the diary.

The activities performed during the protocol were designed for each child based on the results obtained on the PMAL scale and aimed to improve the use of the most affected upper limb during functional tasks, such as eating

and wearing clothes. The activities followed the principles of CIMT, being: task-oriented training with progression of the difficulty of the task (task practice and shaping); constraint of the more functional upper limb; and transfer of gains achieved during training to the real[17].

Additionally, the parents were instructed to fill the task diary. Daily tasks were determined based on needs of each participant according to the PMAL score obtained. The parents were instructed to incorporate these activities on the child's daily life, and take not the activities that the child was able to perform on each day.

RESULTS

A descriptive analysis of the results obtained to each variables of interest are described in percentage of change according to each participant performance. The inter-observer agreement index was 83.33%.

Reach-to-grasp ability

Palm Orientation

Analyzing the palm orientation variable, we observed that on the pre-test the participant 1 performed 50% of the reaches with the hand oriented on horizontal and 50% with hand in oblique. On the immediate post- test, reaching occurred in 60% of the trails with oblique hand, and on the 10 days post-test 100% of reaches were performed with oblique hand. On the, 2 months post-test the participant performed all reaches with hand horizontally (Table 2).

The participant 2 in pre-test executed 66.66% of reaches with horizontal hand and on the immediate post-test performed 50% of the reaches with oblique hand and 50% with vertical hand. Posteriorly, on 10 days post-test 66.66% of the reaches were performed with hand oblique and 33.34% with the hand horizontally. Finally, in the last post-test the participant 2 had similar results to the 10 days post-test and performed 50% of reach with oblique hand and 50% with horizontal hand (Table 2).

In pre-test participant 3 performed all the reaches with vertical hand. On the immediate post-test, and on 10 days post-test, all the reaches were performed with the hand in oblique position (Table 2).

The participant 4 performed 50% of the reaches with hand horizontally and 50% with hand in oblique position on pre-test. On the immediate and 10 days post-test this participant reached 66.66% with oblique hand and in the last post-test we observed an increase in the quantity of reaches, when this participant performed 66.66% of the reaches with oblique hand and 33.34% with vertical hand.

Table 2 – Palm orientation during the accomplishment of the reaches in the affected limb.

	Palm orientation in the affected limb (%) *											
	Pre-test			Immediate post-test			10 days post-test			2 months post-test		
	H	O	V	H	O	V	H	O	V	H	O	V
P1	50	50	0	40	60	0	0	100	0	100	0	0
P2	66,66	33,34	0	0	50	50	33,34	66,66	0	50	50	0
P3	0	0	100	0	100	0	0	100	0	0	100	0
P4	50	50	0	33,34	66,66	0	33,34	66,66	0	0	66,66	33,34

P1= participant 1, P2= participant 2, P3= participant 3, P4= participant 4. H= horizontal hand, O= oblique hand, V= vertical hand. *All data presented in %.

Surface of contact of the hand and fingers

Regarding the distal adjustment of the surface of contact of the hand and fingers, no differences were observed over time between all assessments, since in all participants touched the cup with the ventral surface of the hand and fingers since the pre-assessment.

Hand opening

When observing the hand opening at the touching time (Table 3), it is observed that in pre-test all participants performed the reaches with hand and fingers opened. On the immediate post-test, the participant 4 performed 33.3% of reaches with the hand and fingers semi-open

and 66.6% with hand and fingers open. In the 10 days and 2 months post-test, the participants 2, 3 and 4 reached with hand and fingers open, and specifically during the 2 months pos-test participant 1 performed 67% of reaches with hand and fingers semi-open and 33% with the hand and fingers open.

Table 3 – Opening of the hand at the moment of touch in the affected limb.

	Opening of the hand of the affected limb (%)*											
	Pre-test			Immediate post-test			10 days post-test			2 months post-test		
	F	SA	A	F	SA	A	F	SA	A	F	SA	A
P1	0	0	100	0	0	100	0	0	100	0	67	33
P2	0	0	100	0	0	100	0	0	100	0	0	100
P3	0	0	100	0	0	100	0	0	100	0	0	100
P4	0	0	100	0	33,34	66,66	0	0	100	0	0	100

P1= participant 1, P2= participant 2, P3= participant 3, P4= participant 4. F = closed hand, SA= semi-opened hand, A= open hand. * All data presented in %.

Grasping

Regarding to grasping variable, the reaches were classified as grasp with help of the unaffected upper limb and grasp without help. In general, the number of reaches performed by the affected upper limb with help of the unaffected upper limb were more frequent than the grasping done without help. Participants 2 and 3 had shown improvements on this variable, with participant 2 performed 50% of the reaches without help at immediate and 2 months. On the other hand, the participant 3 has shown improvements on the 10 days post-test performing 50% of the reaches without help of the affected upper limb, however this result was not maintained on the last post-test, when the participant performed 100% of the reaches with help.

Quality of Upper Extremity Skills Test (QUEST)

The results from the QUEST scale shows that after the CIMT protocol all participants improved their scores on the three domains assessed. Among these, it is observed that the grasp domain was the one with the highest improvements, except for participant 4. It is was also observed that, on the dissociated movements domain, the participant 3 did not maintain the gains on the last two post-tests (10 days and 2 months after the end of the protocol), and participant 1 also did not maintain the gains obtained in the protective extension domain, once that the same score was obtained on pre-test and on 2 months post-test after the end of the training (Table 4).

Table 4 – Results from the Quest scale

		P1				P2				P3				P4			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
	1	87,5	91,4	91,4	95,3	83,6	100	96,8	97,7	83	89,8	83	83	86	94	97	93,2
Domain	**2**	52	65	66,6	81	59,2	76	70,3	76	57,4	74	83,3	83,3	80	78	83,3	78
	3	86	98	89	86	82	78	89	89	81	81	89	92	86	88	91	91
Total Score		75,2	84,8	82,3	87,4	74,9	85	85,5	87,5	73,8	81,6	85,1	85,1	84	87	90,4	87,4

A1=Pre-test, A2= Immediate post-test, A3 = 10 days post-test, A4= 2 months post-test. P1= participant 1, P2= participant 2, P3= participant 3, P4= participant 4. Domain 1= motion decoupling; Domain 2= holds; Domain 3= protective extension;

DISCUSSION

The aim of this study was to describe qualitatively the effects of a CIMT protocol in four children with hemiparetic CP, aged between four and eleven-year-old.

Our results show that the CIMT protocol improved the quality of the hand movement on the affected upper limb, with changes observed on the distal adjustments of palm orientation. All participants performed the reaches with oblique or vertical hands in post-test of CIMT protocol which is considered a more functional orientation to the assessed activity. These results can be explained by the high intensity and frequency of the training. Additionally, the activities performed during the training protocol were designed according to each participants necessity, being functional activities, enabling the transference to child's daily activities, as feeding tasks.

We noted that younger children do not performed any reaching with vertical hand after the treatment, being more contrary to perform the protocol activities during the training, and this fact could collaborate to the results observed. This find is not with agreement with the described by Chiu and Ada[18], which observed in systematic review shows that the CIMT therapy is benefic to improve activity and participation in children with CP, and that the age factor did not influence the therapy results.

We also observed an improvement on the frequency of reaching without help in participants 2 and 3, which demonstrates the contribution of the CIMT protocol on the functional use of the affected upper limb in these patients. However, in general the number of reaches performed with help remained higher than those performed without help. The activity of grasping a cup and bringing it to the mouth can be complex to be performed with the affected upper limb in hemiparetic children with CP. To grasp a cup, the child needs to perform a complex movement that involve not only movements of the wrist and finger joints, but also movement components of the elbow and shoulder joints. Studies have shown that children with CP use compensatory trunk movements[19] and have limited elbow extension and supination movements during a reaching task[19,20]. In addition, children with CP have low motor coordination, presenting a lower mean velocity, peak velocity and straightness index, more movement units and longer movement duration, during the task of drinking juice from a glass[21].

On this matter, we can conclude that the CIMT training protocol seems to be a good intervention option aiming to improve the quality of the reach-to-grasp activity in children with hemiparetic CP. In order to potentialize the benefits of this training protocol we suggest that the training activities should incorporate activities related tis core functional movements.

Furthermore, improving the reach-to-grasp ability may have a positive impact on the participation of children with CP. Pashmdarfard and Shervin[22] shows in their study that manual function of children with CP has a moderate and significant relationship with different areas of participation, showing a greater correlation between manual function and daily living activities.

Concerning to QUEST scale results, we observed an improvement in all domains assessed. Among these, the grasp domain had the highest increase in relation to the other domains. These results were observed in all participants except on participant 4, who increased only 3.3 points in this area and did not maintain this gain in the last evaluation.

The domains assessing dissociated movements and weight bearing also shown increments, however these increases were lower when compared to the grasp domain. This find corroborates with the findings from Deluca et al.[1], when after a CIMT protocol of three weeks with eighteen children with CP not significative differences were observed on the QUEST dissociated movements domain. On the contrary, Choudhary et al.[10] realized a four-week training protocol, after which a significant improvement on this QUEST domain was observed.

CIMT training provides a functional improvement to the affected upper limb. Moreover, this therapy modality is able to promote the activation of cortical regions adjacent on the area of the lesion the brain. The restriction of the most functional upper limb forces the use of the affected limb, and together with an intensive and repeated practice seems to promotes in the use of the affected upper limb, as a consequence of the neuronal plasticity of the cortical area responsible for controlling this limb movements[24].

Hoare et al.[25] conducted a study review with the aim to assess the effect of the CIMT therapy in children with CP, being the average training duration around four weeks of training, with the frequency of sessions varying between two and seven days a week. Additionally, the authors pointed that a moderate to high risk of bias among the studies, and the authors conclude that the CIMT therapy seems to be a good option to improve uni and bimanual upper limb function in children with CP when compared to therapies with lower doses, however, when compared with other higher dose interventions the results are similar.

Although our results indicate an improvement on the quality of the reaches and functional use of the upper limbs of children with CP, it is still necessary further studies that investigate important factors such as age related changes, intensity, frequency, and duration of this therapy to clarify the CIMT findings on this population.

CONCLUSION

Based on our findings,, we conclude that the CIMT protocol seems to have the potential to contribute to the improvement of the function of the most affected limb, and that these improvements can be maintained up to two months after the end of the protocol when compared to the results before the training.

Furthermore, we observed that older children were more collaborative than younger ones, thus we suggest that participants age may be a relevant factor

for the results of this type of intervention and the age should be considered when performing this type of intervention. However, more studies with a larger number of participants and randomized clinical trials are necessary for a better understanding of the variables involving this type of therapy (age, intensity, frequency, and duration of therapy) for this population. Further researches are necessary comparing CIMT and its long-term effect with other intervention modalities to a better understanding of its effectiveness.

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