Article

Application of Low-Intensity Modified Constraint-Induced Movement Therapy to Improve the Affecter Upper Limb Functionality in Infantile Hemiplegia with Moderate Manual Ability. Case Series

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Abstract: Objective: To assess the functionality of the affected upper limb in children diagnosed with hemiplegia aged between 4 and 8 years after applying low-intensity modified constraint-induced movement therapy(mCIMT). Methods: Prospective case series study. A mCIMT protocol was applied for five weeks, with two hours of containment per day. The study variables were: quality of movement of the upper limb, spontaneous use, participation of the affected upper limb in activities of daily living, dynamic joint position, grasp-release action, grasp strength, supination and extension elbow movements. Four measurements were performed, using the QUEST scale, the SHUEE Evaluation, a hand dynamometer and a goniometer. Results: The sample was composed of 8 children with moderate manual ability. Statistically significant differences were detected in all the studied variables ($p<0.05$). The greatest increase occurred in spontaneous use from assessment 1-4 ($p = 0.01$), reaching 88.87% active participation in bimanual tasks. The quality of movement of the upper limb obtained a significant value due to the increase in dissociated movements and grasp ($p = 0.01$). Conclusion: A low dose (50 hours) of mCIMT increased the functionality of children diagnosed with congenital hemiplegia between 4 and 8 years of age with moderate manual ability.

Keywords: family; infantile hemiplegia; modified Constraint-Induced Movement Therapy; Physical Therapy modalities; upper extremity.

1. Introduction

Infantile hemiplegia is a subtype of infantile cerebral palsy, characterized by the affectation of one of the hemibodies as a consequence of brain injury. Its prevalence is 1 case per 1,300 lived births[1]. There is more affectation of the upper limb than the lower limb due to the alteration of the corticospinal tract. The affected hand has a deficit in proprioception and tactile perception, which hinders fine motor skills, generally those of the fingers and the strength exerted by them[2]. Sensory

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abnormalities, weak grasp and loss of manual ability (fine movements) may appear, specifically in the fingers, with slower movements, poorer coordination and longer phases associated with mirror movements. This leads to a decrease in the use of the affected hand and often interferes with the manual ability of the healthy upper limb[3] .

From early childhood, children with hemiplegia, even the least affected, use their healthy hand as the dominant hand in all tasks. Therefore, they learn "not to use" their affected upper limb, which is known as developmental disregard[4] . This "non-use" of the affected upper limb produces an increase in muscle tone in the affected segment, poor motor control, decreased active and passive range of motion, generalized weakness and delayed musculoskeletal maturation. The non-use affectation is caused by neural dysfunction as a result of brain injury. This neuronal alteration[5] can be improved through the activation of certain brain areas that remained inactive after the brain lesion and also through experience and learning (trial-error).

Thus, in order to improve the affected upper limb "non-use", Constraint-Induced Movement Therapy (CIMT) is used[6,7] , which consists in constraining the healthy upper limb with a whole or partial containment (glove), thus promoting the use of the affected upper limb in activities of daily living. The programmed tasks integrate the repetition of the motor action with a variety of exercises. There are a variety of protocols used for CIMT, with the most widely used in pediatrics being those based on modified Constraint-Induced Movement Therapy (mCIMT), which constrain the healthy upper limb for less than 3 hours[8–10] . McConnell et al.[11] found that a less intensive treatment (63 hours of treatment over 21 days) produced similar benefits compared to a more intensive approach (126 hours of treatment over 21 days). Functional gains may be feasible for some children with a less intense program adjusted to 20 hours of therapy in more than two consecutive weeks. According to Schweighofer et al.[12] , the existence of a "functional threshold" would be necessary for the maintenance of functionality after therapy, below which the use of the upper limb decreases while the benefits to the individual remain above such threshold. It would be useful to determine the specific doses of therapy in each patient.

For this reason, we consider assessing the functionality of the affected upper limb in children diagnosed with congenital hemiplegia with moderate manual ability between 4 and 8 years of age after applying low-intensity modified constraint-induced movement therapy (50 hours).

2. Materials and Methods

This is a case series, prospective and longitudinal study with non-probability sampling (clinical.gov NCT02178371). The study was approved (060-13) by the ethics committee of the CEU-San Pablo University of Madrid in accordance with the Declaration of Helsinki of the World Medical Association. Before initiating the study, an informed consent form was given to the children's families to participate, which guaranteed the right to withdraw from the study at any time, if required by the participants.

The inclusion criteria were: medical diagnosis of left/right congenital infantile hemiplegia, age between 4 and 8 years, lack of activity of the affected upper limb, exceeds 10º extension in the metacarpophalangeal and interphalangeal joint, completes the 20º extension of the wrist of the affected upper limb, adequate cognitive development to understand the verbal orders given for the execution of tasks and cooperation in their execution. In the same way, the exclusion criteria were: visual problems that prevented the individual from carrying out the intervention, suffering from

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significant balance disturbances that put the child at risk of falling as a consequence of having the healthy upper limb contained, presenting uncontrolled epilepsy, having received botulinum toxin within 6 months prior to the intervention.

All the children were selected according to the inclusion criteria by their rehabilitation doctor of the "Virgen de la Salud" Hospital in Toledo for the execution of the therapy.

Materials and Methods should be described with sufficient details to allow others to replicate and build on published results. Please note that publication of your manuscript implicates that you must make all materials, data, computer code, and protocols associated with the publication available to readers. Please disclose at the submission stage any restrictions on the availability of materials or information. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

Research manuscripts reporting large datasets that are deposited in a publicly available database should specify where the data have been deposited and provide the relevant accession numbers. If the accession numbers have not yet been obtained at the time of submission, please state that they will be provided during review. They must be provided prior to publication.

Interventionary studies involving animals or humans, and other studies require ethical approval must list the authority that provided approval and the corresponding ethical approval code.

2.1. Intervention Method

The study was carried out in a period of 5 weeks of treatment, containing the healthy upper limb for 2 hours per day (not continuously) from Monday to Friday. The intervention was carried out by the family at home. Previously, an informative meeting was held with the parents, in which all the details of the study were explained to them and a program of unimanual activities was given to them to be executed with the affected upper limb every treatment week. The parents of the children were instructed to correctly carry out the intervention avoiding possible errors during the treatment protocol. The weekly exercises, the containment technique and its correct use were also taught to them.

The containment applied was partial, such as a glove or a bandage[13] . In this way, manipulation with the healthy hand was prevented and the wrist and elbow joints were also free to allow the child to react effectively to an external disturbance (Figure 1).

Figure 1. Child with left hemiplegia wearing a bandage as a partial containment in the right hand (dominant hand). In this task, the child is working the grasp-release action.

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Each week, the therapist and the parents of the participants had a meeting to follow-up the tasks and solve problems. The parents were asked to fill out a table with the performed tasks, completing these with photographs and videos of the tasks carried out daily and the execution time.

2.2. Data Collection

Four assessments were performed to measure the study variables and to compare the results before, during and after the intervention (Figure 2).

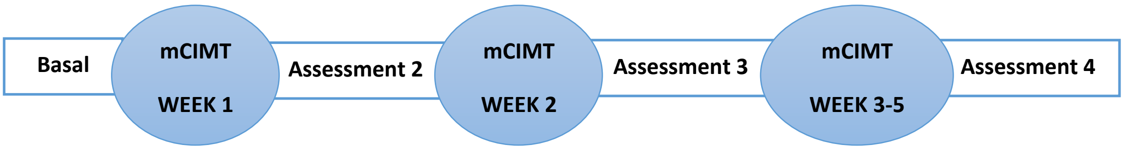

Figure 2. Representation of the assessment number in the 5 weeks of treatment (mCIMT).

2.2.1. Quality of movement and bimanual dexterity of both upper extremities

The Quality of upper extremity test (QUEST)[14–16] was used, validated for children with neuromotor dysfunction with spasticity from 18 months to 8 years of age. It provides a numerical value that is obtained from the mean of the percentages in 36 items distributed in four categories: dissociated movements, grasp, weight bearing and protective extension of both extremities. It takes a value from 0 to 100, and can be expressed in percentages (%).

2.2.2. Active extension of the wrist and active supination of the forearm in the affected upper limb

Both variables were measured with an arm goniometer[17] , making three measurements for each variable and selecting the best result. The measurements were made with the child sitting. Wrist extension was measured with elbow flexion, with the child leaning on a table to decrease muscle tension and associated reactions. Supination was measured with the forearm close to the body, avoiding trunk compensations to gain greater joint width.

2.2.3. Grasp strength in the affected hand

This was measured using a hand dynamometer[18] with a scale between 0 and 150 that expressed grasp strength in PSI (pound per square inch, 1psi = 0.0703kg / cm^2). The test was performed with the child sitting in a chair and with their affected forearm resting on a table to give stability to the upper limb (Figure 3). The children were asked to press the dynamometer as hard as possible to record the measurement.

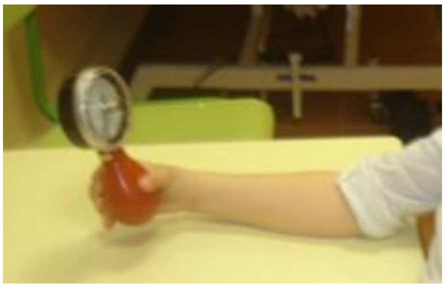

Figure 3. Grasp strength measurement with a hand dynamometer.

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2.2.4. Spontaneous use, dynamic positioning of the affected upper limb, grasping and releasing action (wrist position in neutral flexion-extension), and level of functionality and integration of the affected upper limb in various activities of daily living

The Shriners Hospital for Children Upper Extremity Evaluation (SHUEE)[16,19] was used to obtain the values in the four measurements. This evaluation consists in videotaping the children while they execute a series of tasks to observe the functionality and the joint alignment of the affected upper limb, and it has been validated for use in children with hemiplegia aged between 3 and 18 years. The results are expressed in percentages, with 100% being the best result.

The level of functionality and participation of the patient's upper limbs was determined through the SHUEE assessment as dependent, assisted or independent. Activities of daily living, such as dressing upper limbs, dressing lower limbs, buttoning, putting on socks, putting on shoes, putting on splints and personal hygiene were assessed.

2.3. Statistical analysis

The statistical program SPSS version 20.0 for Windows was used. The results are shown as median and quartiles Q1-Q3 with a 95% confidence interval. The results were compared by variable with the non-parametric Friedman test. Subsequently, a Wilcoxon pair test was performed on those variables that presented statistical significance. Those with a p-value <0.05 were considered as significant values. The qualitative variable of "functionality" was turned into a quantitative variable, graduating it in 5 levels, from 0 = worst functionality to 4 = maximum functionality (Table 1).

Table 1. Description of the functionality levels.

Dependent	Value 0. Needs help from an adult (does not perform the action).
Assisted	**Value 1.** Needs help from an adult (partially performs the action).
Independent	**Value 2.** Uses the healthy upper limb exclusively. **Value 3.** Uses the upper limb to provide stability. **Value 4.** Uses both upper limbs to execute the action.

3. Results

The sample consisted of 8 children, 50% males and 50% females, diagnosed with congenital hemiplegia. Of the entire sample, 62.5% had affectation of the left upper limb. The average age was 6 years, with a standard deviation of 1.77 years. After assessing the motor ability of the children, they were classified at level I in the Gross Motor Function Classification System (GMFCS)[20] and at level II in the manual ability classification system (MACS)[21]

3.1. Quality of movement of the upper limb

The total score in the quality of movement in the upper limbs obtained an increase of 94.07%. All the variables that compose it, i.e., dissociated movements, grasp, weight bearing and protective extension, showed statistical significance (p = 0.00) in the Friedman test (Table 2).

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Table 2. Friedman test for the quaility of movement in the upper limbs.

Variables	Results			Friedman test	
	Q1	Median	Q3	statistical	P value
Quality of movement in upper limbs (total score)					
Baseline	63.55	74.16	83.00	24.000	0.000*
2nd assessment	77.18	83.32	88.49		
3rd assessment	84.42	88.70	91.42		
4th assessment	90.32	94.07	94.92		
Disociated movements					
Baseline	53.90	59.38	80.48	23.538	0.000*
2nd assessment	73.83	75.00	82.82		
3rd assessment	81.24	83.60	87.11		
4th assessment	84.77	89.84	91.79		
Grasp					
Baseline	46.30	62.97	76.86	21.808	0.000*
2nd assessment	59.26	79.60	87.96		
3rd assessment	63.89	87.03	91.67		
4th assessment	75.005	96.30	96.30		
Weight Bearing					
Baseline	76.50	87.00	93.50	19.154	0.000*
2nd assessment	85.50	98.00	99.50		
3rd assessment	93.00	97.00	99.50		
4th assessment	96.00	99.00	100.00		
Protective extension					
Baseline	75.00	80.56	90.27	17.431	0.001*
2nd assessment	79.17	83.34	96.53		
3rd assessment	84.73	90.27	97.92		
4th assessment	92.36	94.44	99.31		

*statistically significant when p value <0.05; Quality of Movement measured with QUEST scale. Results expressed in median (percentages %) and quartiles Q1 and Q3.

Dissociated movements and grasp obtained significant changes for all pair comparisons with a p value <0.03 (Table 3). No statistically significant differences were found for weight bearing between the second and third measurements (p = 0.14), second and fourth measurements (0.10) or third and fourth measurements (p = 0.11), nor for protective extension between the baseline and second measurements or second and third measurements (p = 0.07).

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Table 3. Wilcoxon test for the quality of movement in the upper limbs (QUEST).

Variables	Wilcoxon test	
	statistical	P value
Quality of movement in upper limbs (total score)		
Baseline –2nd assessment	-2.521	0.012*
Baseline– 3rd assessment	-2.521	0.012*
Baseline – 4th assessment	-2.521	0.012*
2nd assessment- 3rd assessment	-2.521	0.012*
2nd assessment – 4th assessment	-2.521	0.012*
3rd assessment- 4th assessment	-2.521	0.012*
Disociated movements		
Baseline – 2nd assessment	-2.524	0.012*
Baseline – 3th assessment	-2.521	0.012*
Baseline – 4th assessment	-2.521	0.012*
2nd assessment – 3th assessment	-2.201	0.028*
2nd assessment- 4th assessment	-2.524	0.012*
3rd assessment- 4th assessment	-2.527	0.012*
Grasp		
Baseline – 2nd assessment	-2.533	0.011*
Baseline – 3rd assessment	-2.527	0.012*
Baseline – 4th assessment	-2.527	0.012*
2nd assessment – 3rd assessment	-2.200	0.028*
2nd assessment – 4th assessment	-2.384	0.017*
3rd Assessment- 4th assessment	-2.384	0.017*
Weigth bearing		
Baseline – 2nd assessment	-2.536	0.011*
Baseline – 3rd assessment	-2.524	0.012*
Baseline – 4th assessment	-2.521	0.012*
2nd assessment – 3rd assessment	-1.461	0.144
2nd assessment – 4th assessment	-1.633	0.102
3rd assessment – 4th assessment	-1.604	0.109
Protective extension		
Baseline – 2nd assessment	-1.841	0.066
Baseline – 3rd assessment	-2.207	0.027*
Baseline – 4th assessment	-2.379	0.017*
2nd assessment – 3rd assessment	-1.826	0.068
2nd assessment – 4th assessment	-2.207	0.027*
3rd assessment – 4th assessment	-2.023	0.043*

*statistically significant when p value < 0.05.

3.2. Grasp strength

The Friedman test showed significance in all assessments (p = 0.00) (Table 4).

Table 4. Friedman test grasp strength

Variable: Grasp strength	Results			Friedman test	
	Q1	Median	Q3	statistical	P value
Baseline	1.00	2.00	2.75	20.069	0.000*
2nd assessment	1.00	2.00	2.75		
3rd assessment	1.25	2.00	3.75		
4th assessment	2.25	3.00	4.50		

*statistically significant when p value < 0.05. Results expressed in median measured in PSI units and quartiles Q1 and Q3.

The largest increase observed occurred from the third to the fourth measurement, with 1 PSI. All comparisons between measurements were statistically significant (p <0.05), except between the baseline and second measurements (p = 1) (Table 5).

Table 5. Wilconxon test for grasp strength

Variable: grasp strength	Wilcoxon test	
	statistical	Sig.
Baseline – 2nd assessment	.000	1.000
Baseline – 3rd asssessment	-2.000	0.046*
Baseline – 4th assessment	-2.640	0.008*
2nd assessment – 3rd assessment	-2.000	0.046*
2nd assessment – 4th assessment	-2.640	0.008*
3rd Assessment – 4th assessment	-2.449	0.014*

*statistically significant when $p < 0.05$.

3.3. Active elbow extension and forearm supination

Both variables increased their value in each of the assessments carried out, obtaining an increase of 21º for elbow extension between the baseline and fourth measurements (p = 0.011), and an increase of 11.50º for the supination of the forearm (p = 0.011) between the baseline and fourth measurements (Tables 6-7).

Table 6. Friedman test for active elbow extension and forearm supination

Variable: active elbow extension	Results			Friedman test	
	Q1	Median	Q3	Statistical	P value
Baseline	10.00	12.50	43.75	23.423	0.000*
2nd assessment	20.00	22.50	50.00		
3rd assessment	22.75	27.50	54.50		
4th assessment	25.75	33.50	64.25		
Active forearm supination					
Baseline	35.50	70.00	75.00	23.416	0.000*
2nd assessment	45.00	75.00	80.00		
3rd assessment	53.50	76.50	82.25		
4th assessment	58.75	81.50	87.75		

*statistically significant when $p < 0.05$. Results expressed in median (measured in degrees of movement) and quartiles Q1 and Q3.

Table 7. Wilcoxon test for active elbow extension and forearm supination.

Variables	Wilcoxon test	
	Statistical	P value
Active elbow extension		
Baseline - 2nd assessment	-2.565	0.010*
Baseline - 3rd assessment	-2.533	0.011*
Baseline - 4th assessment	-2.536	0.011*
2nd Assessment - 3rd assessment	-2.456	0.014*
2nd assessment - 4th assessment	-2.536	0.011*
3rd assessment - 4th assessment	-2.375	0.018*
Active forearm supination		
Baseline - 2nd assessment	-2.588	0.010*
Baseline - 3rd assessment	-2.536	0.011*
Baseline - 4th assessment	-2.524	0.012*
2nd Assessment - 3rd assessment	-2.032	0.042*
2nd assessment - 4th assessment	-2.536	0.011*
3rd assessment - 4th assessment	-2.527	0.012*

*statistically significant when $p < 0.05$.

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3.4. Spontaneous use, dynamic joint position of the affected upper limb, grasp and release action (wrist position in neutral flexion-extension), and level of functionality and integration of the affected upper limb in different activities of daily living.

Spontaneous use increased in all evaluations, reaching 88.87% in the fourth measurement, as well as dynamic joint position and grasp-release action with different wrist positions, with 88.20% and 91.67%, respectively. These three variables showed statistical significance in the Friedman test (Table 8).

Table 8. Friedman test for spontaneous use, dynamic joint position and grasp-release action meausured with SHUEE.

Variables	Results			Friedman test	
	Q1	Median	Q3	Statistical	P value
Spontaneous use in affected upper limb					
Baseline	49.45	70.00	87.78	18.932	0.000*
2nd assessment	58.34	85.56	95.00		
3rd assessment	72.78	87.78	95.55		
4th assessment	87.11	88.87	97.22		
Dynamic joint position					
Baseline	48.24	77.78	86.81	20.918	0.000*
2nd assessment	75.35	80.56	89.93		
3rd assessment	71.87	85.44	91.32		
4th assessment	84.03	88.20	92.71		
Grasp-release action					
Baseline	50.00	58.34	91.67	13.568	0.004*
2nd assessment	54.17	75.00	95.83		
3rd assessment	66.67	83.33	100.00		
4th assessment	83.33	91.67	100.00		

*statistically significant when $p < 0.05$. Results expressed in median (measured percentages %) and quartiles Q1 and Q3.

The pairwise comparison (Table 9) showed that, in spontaneous use, the values of the second and third measurements were not significant when compared with the values of the fourth measurement. In dynamic positioning, only the difference between the second ($p = 0.06$) and third ($p = 0.09$) measurements was not significant. Grasp-release action was only significant between the baseline and fourth measurements ($p = 0.03$) and between the second and fourth measurements ($p = 0.04$).

Table 9. Wilcoxon test for spontaneous use, dynamic joint position and grasp-release action measured with SHUEE.

Variables	Wilcoxon Test	
	Statistical	P value
Spontaneous use of affected upper limb		
Baseline - 2nd assessment	-2.371	0.018*
Baseline - 3rd assessment	-2.366	0.018*
Baseline - 4th assessment	-2.521	0.012*
2nd assessment - 3rd assessment	-2.201	0.028*
2nd Assessment - 4th assessment	-1.963	0.050
3rd Assessment- 4th assessment	-1.690	0.091
Dynamic joint position		
Baseline - 2nd assessment	-2.366	0.018*
Baseline - 3rd assessment	-2.521	0.012*
Baseline - 4th assessment	-2.521	0.012*
2nd assessment - 3rd assessment	-1.183	0.237
2nd Assessment - 4th assessment	-2.366	0.018*
3rd Assessment- 4th assessment	-2.023	0.043*
Grasp-release action		

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Baseline - 2nd assessment	-1.414	0.157
Baseline - 3rd assessment	-1.890	0.059
Baseline - 4th assessment	-2.226	0.026*
2nd assessment - 3rd assessment	-1.342	0.180
2nd Assessment - 4th assessment	-2.041	0.041*
3rd Assessment- 4th assessment	-1.857	0.063

* statistically significant when $p < 0.05$.

An increase was observed in all the variables of functionality and integration of the affected upper limb in various activities of daily living. All increases were statistically significant ($p < 0.05$), except for "buttoning buttons", where $p = 0.163$ (Table 10).

Table 10. Upper limb participation in activities of daily living (SHUEE).

Variables	Results			Friedman test	
	Q1	Median	Q3	Statistical	P value
Upper limbs dressing					
Baseline	2.25	3.50	4.00	10.355	0.016*
2nd assessment	2.25	3.50	4.00		
3rd assessment	3.25	4.00	4.00		
4th assessment	4.00	4.00	4.00		
Lower limbs dressing					
Baseline	2.25	3.00	3.00	15.245	0.002*
2nd assessment	3.00	3.00	3.75		
3rd assessment	3.00	3.00	4.00		
4th assessment	4.00	4.00	4.00		
Put on the splints					
Baseline	1.00	3.00	3.75	9.923	0.019*
2nd assessment	1.00	3.00	3.75		
3rd assessment	1.00	3.00	4.00		
4th assessment	1.50	4.00	4.00		
Put on the shoes					
Baseline	2.00	2.00	3.50	15.188	0.002*
2nd assessment	2.00	2.00	3.75		
3rd assessment	3.00	3.00	4.00		
4th assessment	3.25	4.00	4.00		
Put on the socks					
Baseline	3.00	3.00	3.75	15.000	0.002*
2nd assessment	3.00	3.00	3.75		
3rd assessment	3.00	4.00	4.00		
4th assessment	4.00	4.00	4.00		
Button up					
Baseline	.00	1.00	3.00	5.118	0.163
2nd assessment	.00	1.50	3.00		
3rd assessment	.00	1.50	3.75		
4th assessment	.00	1.50	4.00		
Hygiene					
Baseline	2.00	2.00	2.00	15.000	0.002*
2nd assessment	2.00	2.00	2.00		
3rd assessment	2.00	2.50	4.00		
4th assessment	2.25	4.00	4.00		

*statistically significant when $p < 0.05$. Results expressed in median (measured with SHUEE from 1 to 5) and quartiles Q1 and Q3.

In the pairwise comparison of the measurements for the action of dressing the upper limbs and putting on the orthoses, no statistical significance was detected ($p > 0.05$). In the action of dressing the lower limbs, statistically significant differences were obtained in all assessments, except between the baseline and second measurements and between the second and third measurements ($p = 0.16$). In

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the action of putting on shoes, significant differences were found between the baseline and third measurements (p = 0.32), basal and fourth measurements (p = 0.06) and second and fourth measurements (p = 0.10). In the action of putting on socks, the differences between the baseline and second measurements (p = 1) and between the third and fourth measurements (p = 0.08) were not significant. Regarding personal hygiene, only the changes between the baseline and fourth measurements and between the second and fourth measurements were significant (p = 0.02) (Table 11).

Table 11. Wilcoxon test for upper limbs participation in the task of daily living (SHUEE)

Variables	Wilcoxon test	
	statistical	P value
Upper limbs dressing		
Baseline - 2nd assessment	0.000	1.000
Baseline - 3rd assessment	-1.633	0.102
Baseline - 4th assessment	-1.857	0.063
2nd assessment -3rd assessment	-1.633	0.102
2nd assessment - 4th assessment	-1.857	0.063
3rd assessment - 4th assessment	-1.414	0.157
Lower limbs dressing		
Baseline - 2nd assessment	-1.414	0.157
Baseline - 3rd assessment	-2.000	0.046*
Baseline - 4th assessment	-2.530	0.011*
2nd assessment -3rd assessment	-1.414	0.157
2nd assessment - 4th assessment	-2.449	0.014*
3rd assessment - 4th assessment	-2.000	0.046*
Put on the splints		
Baseline - 2nd assessment	0.000	1.000
Baseline - 3rd assessment	-1.633	0.102
Baseline - 4th assessment	-1.857	0.063
2nd assessment -3rd assessment	-1.633	0.102
2nd assessment - 4th assessment	-1.857	0.063
3rd assessment - 4th assessment	-1.414	0.157
Put on the shoes		
Baseline - 2nd assessment	-1.000	0.317
Baseline - 3rd assessment	-2.121	0.034*
Baseline - 4th assessment	-2.271	0.023*
2nd assessment -3rd assessment	-1.890	0.059
2nd assessment - 4th assessment	-2.251	0.024*
3rd assessment - 4th assessment	-1.633	0.102
Put on the socks		
Baseline - 2nd assessment	.000	1.000
Baseline - 3rd assessment	-2.000	0.046*
Baseline - 4th assessment	-2.333	0.020*
2nd assessment -3rd assessment	-2.000	0.046*
2nd assessment - 4th assessment	-2.333	0.020*
3rd assessment - 4th assessment	-1.732	0.083
Hygiene		
Baseline - 2nd assessment	0.000	1.000
Baseline - 3rd assessment	-1.890	0.059
Baseline - 4th assessment	-2.333	0.020*
2nd assessment -3rd assessment	-1.890	0.059
2nd assessment - 4th assessment	-2.333	0.020*
3rd assessment - 4th assessment	-1.633	0.102

*statistically significant when p value < 0.05

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4. Discussion

The deterioration of hand functionality causes a weakness present in the execution of activities of daily living in children with hemiplegia. There is an alteration compared to the healthy upper limb that manifests in the general slowness of movement, discontinuous movements, variability in the trajectory of the hand with compensations of the trunk and the presence of inadequate coordination in the grasp strength of the affected hand[22] . The improvement in grasp strength and stability occurs from the third to the fourth measurement due to an increase in hand strength. The increase was observed only in the last measurement, which could be due to the need for longer treatment time (5 weeks of intervention). These children with impaired fine motor adjustment, lack of finger dissociation, and deficient proprioception in their affected hand, had greater experience (trial-error) to adapt the grasp to the shape, texture and weight of the object, allowing the execution of a previous thinking strategy (anticipatory control) to achieve precision in the grasp and adjustment of the strength to grasp the object adequately. The improvement of grasp stability and strength allows a functional grasp when picking up objects of different characteristics, and holding them while performing selective and precision activities, such as throwing a small ball at a target, keeping the fork steady with the affected hand and bringing food to the mouth during the feeding phase. Most children with unilateral brain injury do not develop adequate grip strength in the affected upper limb to coordinate one-handed activities. There is a pathological pattern or an immature state of grasp for their age, leading to an inadequate synergy of the coordination strength that is related to the deterioration of the manual ability of the affected hand depending on the level of injury[23] .

When the child does not receive treatment, the choice of using the upper limbs to carry out a unimanual action will depend on the characteristics of the injury, levels of disability, experience and level of frustration and motivation in carrying out activities, among other factors. Learning "not to use" the unaffected upper limb by means of mCIMT intervention can provide an increased spontaneous participation of the affected upper limb in unimanual and bimanual tasks[12] , observed in all measurements performed by Shuee evaluation. The greatest increase was observed from the first to the second measurement, reaching 15.56% of the total value obtained in the last measurement, being 18.87% for the median. This suggests that, when children do not depend on their dominant hand, they learn to use their affected upper limb early and acquire a greater representation within their body schema, developing functional strategies for the execution of daily tasks that allow them to overcome the "disuse" of the affected upper limb due to a lack of integration. Spontaneous use continued to evolve throughout the intervention as the children overcame the lack of experience of use. The improvement in functional performance was reflected in activities of daily living, where a degree of independence and greater participation of the affected limb was reached in the last measurement for the execution of the tasks of dressing upper limbs and lower limbs, putting on socks, shoes and splints, and personal hygiene. The activity carried out with the greatest ability and participation of both upper limbs was putting on pants, for which the most significant statistical results were obtained in the pairwise comparison of measurements. The increase in participation of the affected limb observed from the first measurement to the last, and in some activities accentuated in the fourth measurement, was due to an increase in the quality of bimanual coordination, as a result of the greater integration of the affected upper limb. The parents of the participants provided information about the use of the affected limb in their usual

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environment, such as during meals to actively support the healthy limb, without the need for the parents to give a verbal order to the child to use it, execution of school activities, playing (symbolic play with dolls), and in extracurricular activities such as dancing, where greater integration and earlier activation of the affected segment was observed, among others, which allowed reducing frustration and abandoning the disuse of the affected upper limb.

There could be a continuity in the maintenance of the gains obtained in the functionality of the affected upper limb after executing the intervention, since the daily treatment session was carried out at home, simulating the situation of normal life for the child, in addition to the design of the treatment protocol to simulate activities of daily living.

The improvement in the quality of movement was shown by the greater progress in the results obtained between the baseline and fourth measurements of the variables of dissociated movements and grasp. Appreciable benefits were obtained in each measurement produced by the acquisition of a more corrected posture of the trunk, head and shoulders in the execution of the grasp activities, present from the second measurement (after a week of treatment with mCIMT). A dynamic joint position occurred in wrist and elbow extension, increasing the median value for wrist extension by 21º from the baseline to the fourth measurement. In addition, the value reached in the fourth measurement for the median was 81.50º in the active supination of the forearm, allowing for greater control and support of the body structures for the execution of dissociated movements, grasp, weight bearing and protective extension due to the improvement of both active movements. There was a favorable evolution in the dynamic joint position of the affected upper limb due to the gain of active degrees for movement restriction in extension and supination, obtaining an increase for this variable of 10.42% at the end of the treatment. In this way, the activities proposed during the evaluation were performed with greater ease of movement, such as eating a cookie, touching the opposite ear, picking up coins, opening a bottle or throwing a large ball, which requires the selective motor control of certain muscles. In comparison with the results obtained in the quality of movement of the affected upper limb in the present study, we highlight an investigation[24] on mCIMT, which published positive results in the assessment of the quality of movement of motor skills (measured through the Quest scale) using an intervention protocol of 3 weeks of treatment with an intensity of 6 hours per day of restriction and repetitive work. This study demonstrated the effectiveness of the intervention, as it had a larger sample and a control group (18 children with hemiplegia, 9 children in the experimental group and 9 children in the control group).

In 2011, a different study[25] , conducted exclusively with a girl with hemiplegia, used mCIMT for one hour per day for two weeks. No significant results were obtained at the end of the treatment, which was thereby prolonged for one more week of intervention. This last assessment showed an increase in the overall percentage of total quality of movement (also measured by the Quest scale), appreciable in activities that involve the affected upper limb. Thus, the protocol chosen for the intervention and the initial functionality of the patient are two important factors to take into account in increasing the results obtained in the measurements.

Limitations and future lines of research

As this is an uncontrolled trial[26] due to the absence of a control group, it cannot be guaranteed that the observed response (changes produced throughout the intervention with respect to the baseline situation) is exclusively due to the mCIMT protocol used, since other uncontrolled factors may also have an influence on it. Therefore, the effectiveness of the mCIMT in increasing the functionality of the affected upper limb seen in the present study cannot be generalized to the population of children with hemiplegia, and thus the fundamental utility of this study is descriptive. It is important to highlight the statistically significant results obtained in the different studied variables throughout the 5 weeks of the intervention. This suggests that, although there was no control group, it could be inferred that the changes obtained in the improvement of the functionality were due to the efficacy of the treatment, since it was a short period of time, where important differences were observed in the affected upper limb, which is unlikely to occur due to the maturation effect (learning and natural development of the child over time).

This study leads us to open different lines of research, such as including a control group to assess the effectiveness of the treatment in the functionality of the affected upper limb, to verify whether the gains obtained after the intervention are maintained over time (6 months or one year after therapy), and to study the influence of age on the obtained results due to neuronal plasticity and active participation of the subject.

5. Conclusions

A low dose (50 hours) of modified Constraint-Induced Movement Therapy can increase the functionality of children diagnosed with congenital hemiplegia between 4 and 8 years of age with moderate manual ability.

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