Neuroscience Research Progress

Understanding Children with Cerebral Palsy

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Fabrizio Stasolla
Editor

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UNDERSTANDING CHILDREN WITH CEREBRAL PALSY

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UNDERSTANDING CHILDREN WITH CEREBRAL PALSY

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EDITOR

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CONTENTS

PREFACE

Cerebral palsy (CP) is a group of permanent disturbances of the movement and posture due to defects in the fetal or in the immature brain. It usually includes motor disorders frequently combined with sensory difficulties, intellectual impairments, perception abnormalities, communication and behavioral problems, epilepsy, seizures and secondary muscular alterations. Children with CP may present a wide range of disabilities, depending upon their level of functioning. For example, some of them may be unable to walk, some others may present locomotion fluency incapacities, while others may be unsuitable to profitably complete their academic tasks or inappropriate to communicate their personal needs. Furthermore, some of them, although considered within the normal range of intellectual functioning, may be excluded to the literacy process, due to their extensive motor impairments. Accordingly, they constantly rely on caregivers' and parents' assistance with negative outcomes on their social image, desirability, status, and quality of life. A primary rehabilitative objective may be the independence and self-determination of individuals with CP, developmental disabilities, and different levels of functioning. A secondary goal, closely linked to the first one, is the improvement of the children' quality of life. A third goal to be pursued is the caregivers and families' reduction of burden.

Different rehabilitative approaches and/or strategies may be envisaged. For instance, stimulation sessions may be carried out (i.e., including music therapy). Treadmills and physiotherapy may be implemented. Robotics may be used. Assistive technology-based programs may be designed. Aided-alternative and augmentative communication strategies may be adopted.

The current volume provides the reader with an overview of empirical contributions encompassing different approaches to help children with cerebral palsy in daily life. The common goal is to prevent isolation and passivity and to emphasize a person-centered role with a constructive engagement and positive participation s outcome measure of children' quality of life.

Chapter one (Dos Santos Cardoso de Sà & Rabelo) assessed the correlation between postural control and motor performance in 14 children with CP. Seven children with CP were matched with seven peers with typical development. Differences between groups emerged through the use of different measurement scales (e.g., trunk control) with regard to both static and dynamic balance. Additionally, data emphasized differences between sitting and standing posture. The implications were critically discussed.

Chapter two (Borges) examined the efficacy of horse riding simulator on the sitting postural control of children with CP and spastic diplegia. Forty participants were randomly divided in a group using the simulator (RS) and a group performing conventional physical therapy (CT). The horse riding simulator produced significant improvement in the postural control of children in sitting position, additionally showing a higher motor functionality and a better acceptance of the therapeutic intervention.

Chapter three (Kristková Zwingerová & Palaščáková Špringrová) considered evaluation of postural stability in children with cerebral palsy. The goal was to analyze and to compare the influence of the Acral Coactivation Therapy and other individual movement therapies without method intervention. Twenty-four participants were divided in two groups. Postural stability was measured on Alfa stabilometric platform. The benefit of the Acral Coactivation Therapy in children with cerebral palsy consists in working out in positions of motor development using support of the acral parts and the possibility to incorporate these exercises into daily life activities.

Chapter four (Stasolla) presents a case report. A microswitch-based intervention was implemented to promote basic ambulation responses. The participant with cerebral palsy and severe to profound developmental disabilities profitably learned to use the technology. An ABAB reversal design was implemented. During baselines (i.e., A phases) the technology was available but inactive. During interventions (i.e., B phases) a 3 sec positive stimulation was automatically delivered by the system contingently to a step response. Results showed an increased performance during the intervention phases. Indices of happiness recorded as an outcome measure of the participant's quality of life were improved.

Chapter five (Stasolla) illustrates an extension of chapter four. A new microswitch-based programs was implemented to improve locomotion fluency of a child with cerebral palsy and mild to moderate intellectual disabilities was assessed. Additionally, an evaluation of the awareness of microswitch responding was considered. Finally, a social validation procedure was conducted with 40 psychologists as external raters. An ABABACACAB experimental sequence was implemented. A indicated baselines. B indicated contingent intervention phases. C indicated non-contingent control phases. Results showed that the participants improved their performance during the contingent intervention phases and acquired the awareness of microswitch responding. Social raters positively scored the use of such technology.

Chapter six (Stasolla) includes a new technological solution to promote an adaptive responding and decrease a challenging behavior. Microswitch-cluster technology represents basic assistive tecchnology-based programs aimed at pursuing the simultaneous dual goal of promoting an adaptive behavior and decreasing a challenging behavior. An extension of the technology was adopted to a boy with cerebral palsy and sever to profound developmental delays to enhance object manipulation and reduce head tilting. An ABB^1AB^1 experimental sequence was implemented in which A indicated baselines, B indicated the contingent intervention irrespective of the challenging behavior, and B^1 indicated the cluster (i.e., the adaptive responding was positively reinforced only if it occurred in absence of the challenging behavior). Results showed that the participant significantly increased his adaptive responding and reduced the challenging behavior during cluster phases.

Chapter seven (Stasolla) encompasses a final case report. A child with cerebral palsy and moderate intellectual disabilities was exposed to an assistive technology-based program to enhance academic activities and communication skills. A hierarchical computerized system was implemented. Indices of positive participation were additionally recorded as an outcomes measure of the participant's quality of life. An ABAB reversal design was adopted. Finally, thirty-two support teachers were involved as external raters in a social validation procedure. Results showed that the boy increased his performance and was positively occupied during intervention phases. External raters favorably endorsed the use of such program.

I truly hope by reading this volume caregivers, clinicians, practitioners, families, and researchers may find interesting and enriching insight while daily dealing with their children with cerebral palsy, for both research and practice.

Fabrizio Stasolla

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Chapter 1

POSTURAL CONTROL IN THE STABILITY AND MOTOR PERFORMANCE OF UPPER LIMBS OF CHILDREN WITH CEREBRAL PALSY

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ABSTRACT

Background

In children with CP the postural control is compromised, impairing the independence of these individuals due to changes in motor performance and manual skills compared to typical children.

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Objective

This study verified the correlation between postural control and motor performance in children with PC.

Method

Fourteen children, between six and eleven years old, of both sexes, divided into two groups: group-1: seven children with CP and group-2: seven children with typical motor development. The evaluation of trunk control was through the Segmental Assessment of Trunk Control (SATCo) and the Trunk Control Measurement Scale (TCMS). Reach was assessed by Pediatric Reach Test and the manual skills by the Quality of Upper Extremity Skills Test (QUEST).

Results

The trunk control show similarity between groups (SATCO), and TCMS revealed differences in static sitting balance, sitting dynamic balance, and dynamic range. The execution of the reach is different between the groups in the sitting and standing posture, in both directions. In QUEST the difference is in the tasks of dissociated movement of the upper limbs.

Conclusion

The hemiparetic type resembles the diparetic ones, in trunk control, in range performance and in manual functions, except in activities of dissociated movements and weight support.

INTRODUCTION

Cerebral palsy (CP) or chronic nonprogressive childhood encephalopathy is a group of permanent disorders of the development of movement and posture due to nonprogressive disorders that occurred in the developing fetal or infant brain [1], compromising the structural and functional maturation of the Central Nervous System (CNS) [2], during the prenatal, perinatal or postnatal period [3–6]. The consequences of a lesion for developing brain depend on developmental stage of the infant at time of insult, site and size of the lesion [7]. The lesion occurs the period in which the child has rapid pace of development, compromising the process of skill acquisition. This lesion in the brain reduced the motor repertoire and it may interfere with the function, impairing the performance of activities commonly performed by children with normal development. In the children with CP, the best motor solutions may differ from those of typical developing. Motor disorders generate functional limitation in the performance of activities and may be accompanied by musculoskeletal, sensory, cognitive, perceptual, communicative and behavioral changes [8].

Postural Control: Basic Principles

Postural control is the individual's ability to control the position of the body in space, aiming for stability and postural orientation, influenced directly by the task being performed [9]. The commitment of this control can result in a dependence of the individual on his/her caregivers [10, 11]. Postural stability, or equilibrium, is the ability to project the center of mass within the area encompassed by stability limits, an area also called a support base. This ability to maintain balance varies with the task performed, the biomechanics of the individual and the environment in which he is inserted. Balance is said to be static when the body is at rest and dynamic when the body remains at a constant speed [9]. Posture orientation is the ability to ensure that there is a relationship compatible with the task to be performed between the body segments and between the body and the environment [9].

The body, besides using these abilities, makes use of postural strategies in order to generate a satisfactory response to the desired movement. These strategies may be of the anticipatory type (APA), compensatory or reactive [12]. During day-to-day activities, typical children are constantly performing postural adjustments. These may be of the anticipatory type, in which a muscular activation or inhibition of both trunk and limbs occurs in order to minimize the negative response generated by expected postural imbalance. On the other hand, the compensatory type, in which the muscular activation or inhibition occurs after the occurrence of imbalance due to an unpredictable sensorial stimulus, aiming at the restoration of postural control [13], being dependent on the characteristics of the disturbance intensity, task and stability limits. Therefore, the normal postural control results from a complex interaction between the sensory, neural and musculoskeletal systems, working in an integrated manner in order to control the orientation and stability of the body, influenced by the task being performed and the environment in which it appears [9, 14].

Movement strategies are ways to correct the inadequate response of postural control before, during and after performing some task, to maintain the body in balance. They can be used in two ways, such as feedback and feedforward [9]. These strategies can be of two types: motor, responsible for generating adequate movements; important in the organization of sensory information; and sensorimotor, which integrate sensory information and generate motor responses. All strategies are used for maintenance of postural control [9]. The anteroposterior balance, in vertical posture, can be aided by three types of strategy; in the mid-lateral direction, there is only one strategy, that of weight displacement. The first strategy in the anteroposterior direction, most commonly used, is the ankle strategy, responsible for restoring the center of mass within the base of support, by movements of the joints, especially the ankle. Therefore, there is a need for joint amplitude and strength to be normal. This response usually occurs when the base of support is firm and the imbalance occurs in small amplitudes. The second strategy, from the hip, reestablishes postural stability by producing a broad and rapid movement of the hip joint. It is usually activated in response to large and rapid disturbances, or when the support surface is smaller than the support base and flexible.

The third strategy is step. This is used when the above-mentioned strategies fail, responding to imbalance with the production of a step or jump. These types of strategies in individuals with typical development do not necessarily have to be activated in isolation and in this sequence, and may overlap [9]. Postural control develops differently in children with and without CP, it depends on the severity of the condition [15]. In children with CP, this sequence of acquisitions tends to be less uniform than children with typical development. Primary impairments in CP include loss of selective muscles control, abnormal muscle tone, balance impairment and motor weakness [16]. Children with CP often have compromised postural adjustments, impairing the maintenance of postural control in activities of daily living [12]. They present difficulties in controlling the posture, performing the necessary postural strategies and reacting to imbalances caused by disturbances during the execution of the functional tasks [10]. Therefore, it is common for them to perform their activities in the sitting posture, since it offers a greater degree of stability and a lower degree of freedom to be controlled [17].

The hand, the forearm and the arm, that is, the upper limb, must act coordinately in order to perform a certain task. This requires integration between posture and movement. However, in children with CP, due to motor alterations, this integration is compromised, generating variations in the motor performance of the manual function [10].

Functionality of the Upper Limbs

The use of hands to manipulate, reach and hold objects makes the environment around the child more interactive, allowing the creation and accomplishment of several actions. Thus, it is possible to achieve better motor, social and cognitive development of these individuals [18]. The mobility of the upper limbs results from the association between trunk control and shoulder girdle stability. In children with CP, it is common to find a reduced manual ability as a consequence of motor alterations and/or sensory dysfunctions [19]. The sensory dysfunction arising from injury to the CNS, which may occur in the cerebellum–compromising the processing of sensory information, resulting in ataxia; in the extrapyramidal pathway–reducing the conduction of efferent motor and sensory information; or in the cerebral cortex–impairing the regulation of sensory information [20].

The sensory alterations modify the quality of the kinesthetic and proprioceptive information received by the CNS, which generates insufficient or inadequate responses in the gross and fine motor function, the grip and the dissociated movements of the hands. The hand, the forearm and the arm, that is, the upper limb, must act coordinately in order to perform a certain task. This requires integration between posture and movement. However, in children with CP, due to motor alterations, this integration is compromised, generating variations in the motor performance of the manual function.

DESCRIPTION OF THE STUDY

From the assertion: postural control allows trunk support and limb movement, few studies in the literature detail postural involvement and upper limb function in children with different CP types. The studies show the influence of this control on the daily life of children with CP, but they analyze in only one group and compare with typical children. However, it is known that children with CP differ in their classification regarding lesion, topography and severity, that is, they do not belong to the same classificatory group, since their clinical, physical and functional characteristics differ from one type to the other [7, 8].

The present study was designed to understand whether there are significant differences in trunk control of children with different CP types and different levels of functionality by Gross Motor Function Classification System (GMFCS) [21] and how this trunk control correlates with manual function in different types. The study was designed (1) to verify the postural control, performance on functional reach and upper limb skills in children with CP and children with typical motor development; (2) to verify the postural control and performance in the functional reach in children with CP; (3) to verify the relation of postural control and functional abilities of upper limb in children with CP; (4) to verify the correlation between postural control and abilities upper limb in CP children of different levels of GMFCS; (4) to verify the functional abilities of upper limbs of children with CPs of different levels of GMFCS and (6) to verify the postural control, the performance in the functional reach and the abilities of upper limbs in children with hemiparetic and diparetic CPs.

The findings of this study may influence the decisions made regarding the therapeutic approach, making it more specific for each child with CP. For the evaluation of trunk control, we chose two SATCo and TCMS scales, whose main objective is to evaluate the trunk control in the sitting posture. However, the first one (SATCO) [22] emphasizes the level of control based on the need or not of a support to maintain the posture.

The second scale, TCMS, [23] analyzes the bodily abilities that the child presents. A deficit in trunk control may lead to increased instability, making it difficult to perform activities that require a displacement of the body beyond the base of support. Thus, jokes like reaching and manipulating an object around the body are compromised, restricting the size of the space they can reach. Therefore, children with CP who show impaired balance prefer the sitting posture to perform their activities, requiring less of the postural control, due to the proximity of the center of mass to the base of support, and less of the postural adjustments to remain in position. We chose to use the Pediatric Reach Test (PRT) [24], to evaluate the difference between the functional range in the sitting and standing posture and if there is interference in the performance considering the direction of the anterior and lateral movement.

The manual ability is another aspect to be analyzed, since postural impairment may imply a lower performance of the upper limbs, mainly in activities that required greater axial control and fine motor precision, such as in reaching and holding an object. To do this, we used the Quality of Upper Extremity Skills Test (QUEST) [25], a scale that allows us to say whether there is impairment of manual functionality as a whole, or in only some activities, such as dissociated movement (DM), manual weight (MW) and protection reaction (PR).

Hypotheses

Children with CP have a change in motor development, which may present a compromise in postural control, which results in a deficit in body stability. These changes are more evident in diparetic CP children, due to the involvement of upper limbs and lower limbs, different from the hemiparetic CP that presents motor change in upper limb and lower limb of only one hemibody. The ability to control the body in space depends on the individual, the task and the environment. When performing two activities, with the same individual in the same environment, we see the interference of the task in motor performance. A task carried out in the transverse plane, with displacement of the body in the lateral-lateral direction requires greater control than when carried out in the sagittal plane, displacing in the anteroposterior direction.

The greater the trunk control, the greater the axial stability of the body, thus allowing more precise and coordinated appendicular movements. With a postural impairment, the upper limbs have their functionality impaired, mainly in the distal movements, reaching and unloading of weight. Considering that diparetic CP children have a lower trunk balance, they tend to have a greater deficit in manual function when compared to hemiparetic CP children.

METHOD

We studied 14 children aged 6–11 years old, of both sexes, divided into two groups: cerebral palsy group (CPG) composed of seven children with a diagnosis of CP, diparetic or hemiparetic spastic type, classified into level I or II of GMFCS [21]; and typical developmental group (TDG) with seven typical motor development children. The groups were matched by sex.

The inclusion criteria for both groups were as follows: age between 6 and 11 years and formal consent provided by legal representatives to participate in the study. The specific criteria for CPG were the diagnosis of diparetic or hemiparetic spastic CP; classified as GMFCS with levels I or II; without associated visual and/or auditory deficit, and who understood simple verbal commands. For TDG, the criteria were the absence of motor, perceptual, sensory and cognitive impairment.

The exclusion criterion for CPG was the presence of deformity in the lower limbs and spine that compromised the permanence in the orthostatic posture. For the TDG, the exclusion criteria were: diagnosis of any malformation, genetic syndromes, congenital alterations, postural deformities or alterations that could impair the neuromotor, cognitive and affective development of the child. For both groups, children who have not completed the test protocol for any reason were excluded.

Data collection was started by completing the sample characterization sheet, containing the personal data and GMFCS classification. Children with CPs who were able to walk unrestrictedly, run, jump, and climb ladders without physical assistance were classified as level I. Those who had limitations in walking on uneven ground and long distances, as well as minimal ability in running, jumping and climbing activities Stairs were grouped at level II, as suggested by Palisano et al. [21].

The evaluations followed a sequence: first, the scales that evaluate the trunk control (SATCo and TCMS) [22, 23] followed by the evaluation of the performance in the scope (PRT) and finally the functionality of the upper limbs (QUEST) [25]. The environment was partially controlled, consisting of a closed room with the necessary materials for application of the scales, and the presence of only the examiner, an assistant, the child and his/her guardian, in order to avoid excessive stimuli to the participants that could divert attention.

Clinical Variables

Functional trunk control level obtained by SATCo, which allows the child to move the head or trunk without impairing stability; (2) Level of trunk control obtained by TCMS; (3) Regarding the movement of upper limbs, the variables were: dissociated movements, grip, weight support, protection reaction; (4) Functional range: anterior in the standing and sitting position, and lateral D and E in the sitting or standing position.

Statistical Analysis

Statistical analysis was performed on the basis of the T-student test between CP and TD groups, and within the CPG between hemiparetic and diparetic groups. It was also used the Pearson Correlation Test aiming at the relations between the postural control and motor performance in the different CP types. The values of r in module greater than or equal to 0.9 correspond to a very strong correlation; between 0.7 and 0.9, strong correlation; between 0.5 and 0.7, moderate correlation; between 0.3 and 0.5, weak correlation; between 0 and 0.3, negligible correlation. Significant values were considered for those who obtained significance level $p < 0.05$. The SPSS v.19 software was used for the analyses.

RESULTS

The age at TDG ranged from 6 to 10 years (8 ± 1.63) and in CPG between 6 and 11 years (8.42 ± 1.71). Among the children with CP, three were hemiparetic spastic type and four spastic diparetic, classified in GMFCS with level I and level II respectively. All hemiparetic children had right hemibody involvement.

The results demonstrate the similarity in SATCo trunk control between the TDG and CPG, both of the maximum score obtained in this range (Table 1). In the TCMS, the results showed a significant difference between groups in the three domains evaluated, sitting static balance (SSB) ($p = 0.003$), sitting dynamic balance (SDB) ($p = 0.003$) and dynamic range (Table 1). Although none of them received a maximum score, except in the dynamic range, we see that the TDG presents values higher than CPG, suggesting that they have greater trunk control during limb movement and trunk movement.

The results of the PRT had significant values in the orthostatic position, in the anterior range (AR) (p = 0.018), in the right lateral range (RLR) (p = 0.002) and left lateral (LLR) (p = 0.008). In the sitting posture, in the right lateral range (RLR) (p = 0.023) (see Table 1). This shows that there is a difference in ability between typical children and children with CP in maintaining balance during trunk and upper limb movement in sitting and standing postures.

Table 1. Mean or median and standard deviation of the variables in the TDG and CPG

		TDG	CPG	Test t	P
SATCo (7*)		7	7	-	-
TCMS	SSB (20*)	18.85 ±0.89	16.85 ±1.06	T(12) =11.660	0.003**
	SDB (38*)	22.57 ±3.30	10.66 ±2.88	T(8) =4.420	0.003**
	DR (10*)	10	8 ±1.73	T(12) =6.000	0.022**
PRT	SRPD	77.52 ±8.96	65.35 ±7.54	T(12) =11.664	0,018**
	RLD	71.18 ±5.28	60.19 ±5.50	T(12) =11.980	0.002**
	LLD	72.80 ±8.05	59.75 ±7.34	T(12) =11.899	0.008**
	SPD	89,85 ±7.88	80.66 ±10.21	T(12) =11.278	0.085
	SRLD	67.68 ±6.40	58.74 ±6.47	T(12) =11.999	0.023**
	SLLD	69.28 ±7.79	62.37 ±6.82	T(12) =11.796	0.104
QUEST	DM (100*)	59.13 ±0.58	53.90 ±5.46	T(12) =6.138	0.044**
	MG (100*)	51.31 ±23.75	58.71 ±11.40	T(12) =8.626	0.477
	WS (100*)	93.14 ±18.14	88.57 ±15.39	T(12) =11.690	0.621
	PR (100*)	57.13 ±29.03	64.28 ±11.94	T(12) =7.974	0.564

SSB: sitting static balance; SDB: sitting dynamic balance; DR: dynamic range; SRPD: standing range in the previous direction; RLD: Standing range, in the right lateral direction; LLD: Standing range, in the left lateral direction; SPD: sitting in the previous direction; SRLD: seated range, in the right lateral direction; SLLD: sitting range, in the left lateral direction; DM: dissociated movement; MG: manual grip; WS: weight support; PR: protection reaction.

(*): maximum score of each subdivision of the scales.

(**): significant values.

The manual function evaluated by QUEST had a significant difference between the groups only in the dissociated movement (DM) items (p = 0.044), in the other items the CPG and TDG resembled (Table 1). The correlation between TCMS variables and PRT, with significant values in the correlation of SSB with RLD (r = +0,784, p = 0.001), LLD (r = +0,666, *p* = 0.009) and SRLD (*r* = +0,604, *p* = 0.022). In SDB, this had a significant correlation only with RLD *(r* = +0,680, *p* = 0.031).

The DR was significant when correlating with the reach in the two postures and in the three directions, except in the SLLD (*p* = 0.117). Among these correlations, the only one classified as strong was between SSB and RLR, the others are said to be moderate. Thus, there is indicative that the static balance is related to the ability to reach when in orthostatic posture.

Table 2. Mean, median and standard deviation of the variables studied in CPG between diparetic and hemiparetic individuals

		CPG-D	CPG-H	T Test	P
SATCo (7)*		7	7	-	-
TCMS	SSB (20*)	17,5 ±0,57	16,0 ±1,00	T(5) =3,000	0,103
	SDB (38*)	12 ±3,55	8,66 ±0,57	T(5) =1,565	0,177
	DA (10*)	8,50 ±1,00	7,33 ±2,51	T(5) =2,479	0,513
PRT	SRPD	69,32 ±2,37	60,05 ±9,42	T(5) =2,191	0,227
	RLD	62,58 ±6,00	57,00 ±3,17	T(5) =4,680	0,178
	LLD	63,83 ±7,01	54,33 ±3,28	T(5) =4,441	0,069
	SPD	85,12 ±5,82	74,72 ±13,01	T(5) =2,606	0,299
	SRLD	62,05 ±5,62	54,33 ±5,20	T(5) =4,656	0,124
	SLLD	62,37 ±6,79	62,38 ±8,40	T(5) =3,825	0,998
QUEST	DM (100*)	58,01 ±1,55	48,43 ±2,70	T(5) =2,994	0,012**
	MG (100*)	62,95 ±8,55	53,07 ±14,02	T(5) =3,110	0,357
	WS (100*)	100 ±0,00	73,33 ±10,06	T(5) =2,000	0,044**
	PR (100*)	70,83 ±4,81	55,54 ±13,89	T(5) =2,364	0,190

CPG-D: diparetic children included in the group with cerebral palsy; CPG-H: hemiparetic children included in the group with cerebral palsy. SSB: sitting static balance; SDB: sitting dynamic balance; DR: dynamic range; SRPD: standing range in the previous direction; RLD: Standing range, in the right lateral direction; LLD: Standing range, in the left lateral direction; SPD: sitting in the previous direction; SRLD: seated range, in the right lateral direction; SLLD: sitting range, in the left lateral direction; DM: dissociated movement; MG: manual grip; WS: weight support; PR: protection reaction.

(*): maximum score of each subdivision of the scales.

(**): significant values.

The correlation between TCMS and QUEST variables revealed a significant correlation between SSB (*r* = +0.765, *p* = 0.001) and DR (*r* = +0.638, *p* = 0.014) with DM. The first value indicates strong correlation and the second moderate correlation. These results demonstrate the importance of static trunk balance for upper limb movements, and of these for functional range.

The correlation between GMFCS and QUEST was significant GMFCS and DM ($r = +0.937$, $p = 0.002$) and WS ($r = +0.926$, $p = 0.003$). The two correlations are very strong, suggesting that gross motor function in children with CP is directly associated with their ability to move upper limbs and discharge weight on these limbs.

The analysis between CP types, hemiparetic and diparetic, indicated that the differences between the types occurred only in the MD ($p = 0.012$) and WS ($p = 0.044$) of the QUEST (see Table 2), inferring that both have similarities in the control of trunk, manual function and the ability to perform range in different directions.

DISCUSSION

In this study, we chose not to discuss the motor capacity and functional ability of the upper limb by means of the total score of each scale, since we believe that this value could suppress important and relevant results in the differentiation between CPG and TDG. Analyzing the results of each subdivision delineates a larger focus for items with a significant variable. Thus, these values express the idea that it is possible to have some important changes between the groups, even if the total score does not predict the difference between typical children and children with CP.

This method of analysis was also a way of understanding where the difference between the samples is, in order to facilitate the understanding and give direction to the health professionals during the performance with the children with CP of the hemiparetic and diparetic type. In order to approach the clinical practice, we opted for the use of two scales to evaluate trunk control, SATCo and TCMS, associated to PRT and QUEST, these four scales were applied to justify our hypothesis and confirm our objectives. The main focus of this study was to correlate the postural control with the motor performance of children with GMFCS level I and II

CPs. For that, a sample of typical children, matched by sex and approximate by age, was used to assimilate the difference, if any, between these two populations.

Regarding trunk control, we did not observe a difference between CPG and TDG by the SATCo scale. All participants received maximum scores, demonstrating that even individuals with motor disorders due to encephalopathy can maintain postural control by assuming the sitting without support. This allows to verify that the static and dynamic stability of the body is present in children with CP level I and II of GMFCS. This proximity between the levels of gross motor function may have delimited the values found in SATCo, assessing similarity between trunk control in CPG and TDG. Some readers may consider this proximity as a limitation to justify our initial hypothesis, in which we considered that CPG would have lower trunk control compared to TDG. However, we observe it as a benefit because the results allow to affirm that children of levels I and II have the same postural stability as typical children. The option to use this scale was due to its evaluation principle, allowing the distinction of the postural control according to the segmental level of the trunk [26]. Thus, for its application, it is not necessary that the evaluated ones have control of inferior trunk and they remain in position without support. This fact differs from TCMS. At this scale, the child needs to remain in the seated position without support to be able to carry out the proposed tasks.

This difference between the scales is of paramount importance for the clinical routine because it indicates to the health professional which scale is the best to be used with each individual. I say this, therefore, the TCMS includes only children with CPs of levels I, II and III of GMFCS [23]. Consequently, individuals classified as level IV and V could not have their trunk control assessed by this scale. However, we can use SATCo at all levels of GMFCS. Nevertheless, when choosing between the two scales, we suggest the use of TCMS due to its greater proximity to the functional activities of this population [23].

In the evaluation of trunk control by this scale, we found significant values between the groups. The results show greater stability for typical children in the three subdivisions–SSB, SDB and DR. This allows to verify that they have greater postural control during trunk and limb movement, compared to children with CP [27], thus justifying our first hypothesis. The non-proximity of the values among the groups is based on the complexity of some tasks of this scale. For the execution of certain items, children with CP perform visual changes in posture through muscular compensations. The fact that the movement is not performed in the full range of motion and has postural changes causes them to receive lower scores. These compensations, which are not the focus of this study, but are part of the evaluation of this ladder, appear as an attempt to control the movement and fulfill the initially requested action, thus confirming the stability deficit.

When observing the three parts of the TCMS, we observed that in the SSB and DR, the values of both groups approach, despite the existing difference. A possible explanation for this occurrence is centered on the displacement of the center of mass. The movements of these items occur only in the anteroposterior plane, in which the child finds greater stability, because the base of support in this plane is larger than in the lateral-lateral direction, which is limited by the contact area of the body with the surface. With the increase of the base of support, the mass center finds greater freedom of movement without causing imbalances, allowing the execution of activities in larger amplitudes.

Although these items allow a better balance, CPG presents lower results than TDG. Efficacy in limb movement is related to trunk control ability [26] stabilization of proximal joints and muscle synergism. In children with CP, the intrinsic motor impairment leads to muscle disorders and postural control disorders [2, 27], thus, these individuals lack wide and coordinated movement. Our results obtained with TCMS confirm what Heyrman et al. [23] found in their findings. They state that children with CP have lower scores in the TCMS subdivisions when compared to typical children. They also state that these children with typical development received maximum scores on SSB and DR items, which cannot be verified in our results, since the TDG reached the maximum score only in DR.

The reason for such a difference between the studies is in the maturation stage, by which the children of our sample are passing.

Heyrman et al. [23] observed that the maximum score was only possible in individuals over 11 years of age because in these children, postural control is already said to be mature and similar to that of an adult [9]. However, in this study, children between 6 and 10 years were evaluated; therefore, they are still in the maturation stage of this control, preventing it from reaching a total score. In children with CP, due to the deficit in balance, associated with less activation of postural adjustments [10], these individuals have preference for lower postures that require less postural control [27] during the accomplishment of their daily tasks, in order to obtain greater performance, due to the smaller activation of the control of trunk so that its activities are executed.

With this in mind, we decided to evaluate the ability of reaching through the PRT in different postures, in the anteroposterior and mid-lateral directions, in order to compare the performance of these children. The application of this scale in orthostatism and in the seated position occurred due to the importance of these postures in the accomplishment of the daily tasks. The choice of the two directions was an attempt to approach reality, since the daily tasks go beyond what is around the body, not being restricted to the sagittal plane.

From the results of the PRT, we see the proximity between CPG and TDG in SPD and SLLD, inferring that postural impairment, in this case, does not affect the performance of children with CP compared to typical children. However, there is a significant difference in the range of seated posture in the right lateral direction, which may be explained by the composition of the CPG sample, since three of them are of the hemiparetic type, with motor impairment of the right hemibody, affecting their performance when performing the task on this side. Postural stability is defined as the ability to maintain the center of mass within the limits of stability, or support base [9]. Thus, the larger the support base, the greater the area allowed for oscillation of the center of mass, without generating impending imbalances in the body, we observe this influence in achieving the reach. Children with trunk impairment tend to perform better, that is, distance reached during sitting, because they thus find greater balance, keeping the trunk properly in the course of reaching a target in front of him or at his side without the risk of falls. Because the child needs greater postural control in the orthostatic posture, because in this occurs the center of mass elevation and narrowing of the support base, generating limits in the capacity to maintain stability. A fact that was also found in our study, where we observed that CPG has greater difficulty performing the task when in orthostatism, with a significant difference in SRPD, RLD and LLD, with lower values when compared to TDG.

When we observed all the PRT values in the TDG and CPG, we identified that the distance reached during the range was higher when performed in the anterior direction. Rojas et al. [25] describe that CP children have greater difficulty in maintaining postural control in activities in the mid-lateral direction, presenting greater center-mass oscillation than typical children, both in standing and sitting posture.

This can be interpreted according to the level of requirement of the trunk control for the execution of the task in the mid-lateral direction. We observed that in this direction, it is fundamental to have a higher postural control due to the trunk inclination movement, which shifts the center of mass in a narrow support base, requiring greater activation of the trunk musculature in order to maintain balance. These results confirm our hypothesis that the requirement of trunk control is greater in tasks carried out in the transverse plane than in the sagittal plane.

As previously reported, muscle activation in children with CP is not improved, which may explain the lower values in the lateral range in this group. Associated with this, we have the commitment factor of the members. Although in the diparetic, the injury does not interfere in a great magnitude in the upper limbs, and in the hemiparetic ones it is in only one upper limb, we observed the influence of this motor disorder in the performance of its activities, having inferior results when compared with typical children of the same age and sex.

Due to the relevance of manual function in the children's life, allowing them to handle objects and interact with the environment around them [18], we decided to study the influence of trunk control on this function. For manual skills, postural control is necessary [29], since there is a strong relationship between the appendicular skeleton and the axial skeleton, which, linked by the anatomical, biomechanical and musculoskeletal aspects, allows the movement of these parts of the body [19].

When we consider the importance of trunk control for upper limb movement, and this for performing manual tasks such as reaching and gripping, we apply QUEST to correlate them. In the results of this scale, we observed similarity between the groups in the MG, WS and PR items, with significant difference only in DM items. A possible explanation for this finding is centered in the insufficiency of trunk control during the execution of the movements of the upper limbs, that is, without efficient axial balance, the appendicular skeleton cannot carry out the movements in the extreme amplitudes, limiting their mobility, with impairment in activities daily.

The similarity between the groups in the MG items is due to the requested tasks, they only require hand mobility, without the need for large amplitudes of movement in the other joints of the upper limb, having in some items a forearm projection. Thus, it differs from DM, in which it needs a postural stability to be able to effect isolated movements of the articulations of the upper limbs without the possibility of support. The limb needs to be stabilized and sustained in order to perform the desired task.

While items of DM and MG are performed in a sitting position on the bench, the WS and PR of items are performed in positions and cats sitting in a ring on the floor. Thus, these two items have the foundation of their results infused in the body stability question, because, when adopting these postures, the center of mass approaches the surface and the base of support tends to increase. Therefore, we have approximation values between the groups CP and TD, showing that the CPG is able to affect the movements in the upper limbs and even having trunk control deficient they have protection response when having its center of mass displaced. Above we discuss the results for each scale and compare the values of TDG and CPG. However, we believe that these scales are interconnected, so we correlated them in order to achieve the objectives of this research.

When correlating the information from the TCMS and QUEST, we identified a strong connection between the SSB and DM items, obtaining a direct correlation, that is, the greater the static equilibrium of a child, the more ability it will have to perform the dissociated movements of the upper limbs. Therefore, axial control is indispensable for the freedom of appendicular movements. Having good trunk control results in the adequacy of manual mobility for the functional activities of each individual [9, 27].

The task of reaching also requires postural control, aiming at the restoration of the posture after the displacement of the center of mass. While he was decreased control, the upper limb cannot be raised and directed effectively to the implementation of reach. The same occurs in DM, without adequate control there is impairment of limb mobility. This results in direct and moderate correlation between the DR and DM items, that is, if there is impairment in the mobility of the upper limb, consequently there will be damage in the DR.

The influence of postural control over the execution of the reach was observed to correlate the TCMS and the PRT. In this, we observed a direct correlation between the SSB item and the range in both site station (SRLD item) and orthostatism (RLD and LLD items). In the TCMS, it is also possible to evaluate the reach task, but it is performed only in the seated posture and in the anterior direction. Equality in posture may explain the moderate correlation between DR items with APD, SRLD and SLLD.

Although the PRT also assess the reach in the orthostatic position, it does not prevent it from drawing a direct correlation between the SRPD, RLD, LLD and DR items, showing that if the child is able to achieve the previous reach in the sitting posture, the posture will be able to do the same action when standing and in the lateral direction. It is worth remembering that the correlation between these scales is of moderate degree, being able to have exceptions and differences when analyzing other groups with TD and CP.

As each child with CP is classified according to their gross motor function, we could not help assessing whether it has any influence on their manual ability. Therefore, when correlating GMFCS with QUEST, the results showed a very strong correlation between this classification and the manual function, stating that the lower the level of GMFCS, the higher the functionality of the upper limbs in the DM and WS items.

So far, we have talked about CPG and TDG. However, in CPG, there are two CP classifications regarding topography, diparetic (CP-D) and hemiparetic (CP-H). To avoid generalization of results, and to delineate a closer look at each type, we chose to compare the values of these in the scales evaluated. By comparison, we observed a similarity in trunk control, both in SATCo and in TCMS, that is, the difference in the topography of motor involvement does not cause significant differences between these children with CP. The initial hypothesis of this study was that children with CP-D presented lower postural control due to the topography of the involvement, since they included lower and upper limbs when compared to children with CP-H who had upper limb and lower limb of only one hemibody [20].

However, the SATCo results did not confirm this hypothesis. This scale evaluates the control of the trunk in the sitting posture without movement of the limbs. The lower limbs remain flexed and feet supported on the ground, and the upper limbs are suspended without support [22]. Because there is no movement of the limbs, the site of the motor impairment of these CP children, this would be a possible justification for the results found.

In the TCMS, the results also did not indicate a significant difference between the CP-H and CP-D participants. In this study, CP-H children were classified as level I in GMFCS, which according to Heyrman et al. [23] should present greater control of the static and dynamic balance, compared to children classified as level II. These authors state that the higher the level of impairment of gross motor function, that is, the higher the level in GMFCS, the lower the postural stability. However, this is not what we observed in our results. Despite this, we cannot generalize our findings, as there is a limitation in this study regarding the number of participants and GMFCS levels.

Liao et al. [28] found that CP-D children have a better static balance than dynamic balance. As we did not do this analysis, our study does not confirm this data, but by the absolute values, we observed that the diparetic children present a greater static and dynamic balance in the MSCT as compared to the CP-H children.

The comparison between the CPG samples by the PRT was an attempt to answer the hypothesis that the CP-D would reach lower values than the CP-H, since those have motor impairment on both sides and these on only one side. However, even the change being bilateral in CP-D, they reached higher, but not significant, values than CP-H. One possible explanation for these results is the anatomical distribution of motor dysfunction. In the diparetics, the involvement is more intense in the lower extremities, limbs that remain static during reaching. While the hemiparetic ones have unilateral motor alteration, with involvement of the right hemisphere, then when performing movement in the mid-lateral direction using the MSD, they present a restriction in the amplitude of the movement in this direction.

This explanation based on the topographic difference between children with CP-D and children with CP-H supports the values found in QUEST. In the items of the manual function that require isolated movements of the upper limb, as in the DM and WS, we observe that the values differ between these children, because these items require, besides trunk control, the ability to perform joint movements and weight upper limb right, without contralateral upper limb help. Thus, CP-H children present lower performance as compared to CP-D children.

The importance of trunk control is centered in association with the development of motor function and mobility in children with CP [9, 27]. The need for a detailed evaluation and correlation between the postural control and the functional performance, in order to direct health professionals to the clinical practice focused on the specificities of this population.

The limitation this study was that the findings found and the required conclusions cannot be generalized for children with GMFCS III Cerebral Palsy. The limitation of the study is that the findings found and the required conclusions cannot be generalized for children with GMFCS III Cerebral Palsy.

CONCLUSION

Postural control and motor performance in typical children and children with CP, present similarity in trunk control by SATCo and in manual skills, except for item DM. However, by TCMS, children with CP have lower trunk control, with impairment in static balance and dynamic balance, and that these are associated with lower performance in outreach activities.

The correlation between the TCMS and the QUEST allows to affirm the importance and influence of the postural control in the execution of tasks involving the upper limbs, mainly in activities of movement and isolated movements of these members. Given this, we can say that children with CP need the postural stability to move the upper limbs and reach the objects.

Children with CP-H, classified as level I, are similar to children with CP-D, classified as level II. This approximation between them occurs in trunk control, ability to reach in different directions and postures, and manual functionality, except in DM and WS. Thus, we verified that there is an association between postural control and motor performance in children of levels I and II of GMFCS.

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Chapter 2

THERAPEUTIC EFFECTS OF A HORSE RIDING SIMULATOR IN CHILDREN WITH CEREBRAL PALSY

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ABSTRACT

Purpose

To evaluate the efficacy of horse riding simulator on the sitting postural control of children with spastic diplegia.

Methods

Forty children were randomly divided in a group using the simulator (RS) and a group performing conventional physical therapy (CT). FScan/FMat equipment was used to register maximal displacement in anteroposterior (AP) and mid-lateral (ML) directions with children in sitting position. At the pre and post intervention stage both groups were classified according to the Gross Motor Function Classification System (GMFCS) and, after intervention, by the AUQEI questionnaire (Autoquestionnaire Qualité de vie Enfant Image).

Results

Comparison between groups disclosed statistically significant pos-intervention improvement both in the AP ($p < 0,0001$) as in the ML ($P < 0,0069$) direction in the RS group.

Conclusion

The horse riding simulator produced significant improvement in the postural control of children in sitting position, additionally showing a higher motor functionality and a better acceptance of the therapeutic intervention.

Keywords: cerebral palsy, spastic diplegia, postural balance, horseback riding therapy

INTRODUCTION

The ability of maintain postural control is an important factor in the execution of daily life activities and the independent individual development [1-2]. Although stable posture control and balance are automatic for healthy individuals, this is often a challenge for patients with cerebral palsy (CP) [3]. The presence of spasticity, muscle weakness, musculoskeletal disorders, and poor pelvic movement (with anteroposterior fixation and pelvic retroversion) common to children with CP make sitting postural control worse than in healthy children [4-6].

To maintain sitting posture, children with CP perform stereotyped activation of the extensor (cerebrospinal caudal) muscles, abnormal muscle recruitment (from proximal to distal), and excessive gradation of antagonist muscle activation [1]. This impairs the quality of range that depends on postural control [5]. When the child sits with good control and postural alignment, he or she improves upper limb functionality for reaching, handling, eating, and writing [7-8].

Analyzing postural control and sitting balance may be a way to study the performance of the postural control system of children with CP. These children are known to have neural mechanism changes that affect the pattern of muscle activation and mechanical changes that affect the structure of skeletal alignment [9]. Thus, different therapies are being directed to improve the ability of sitting postural control, aiming to achieve greater therapeutic success and better quality of life for children with CP [10].

Postural Control

Postural control is defined by orienting body segments to maintain upright posture against the force of gravity within a support base against external disturbances [3, 6, 11]. This requires a close relationship between sensory information and motor strategies. Motor strategies are the organization of appropriate movements to control the position of the body in space. Sensory strategies organize sensory information from the visual, somatosensitive and vestibular systems for postural control. Thus, sensorimotor strategies reflect the norms of coordination of the sensory and motor aspects of postural control [12-15].

The ability to produce and apply forces in a coordinated manner in order to control the position of the body in space is essential for postural control. Thus the Central Nervous System (CNS) must activate synergistic muscles in mechanically associated joints to ensure that the forces produced in one joint do not cause instability in other areas of the body. The CNS internally represents the body's position in space, in reference to the efficient behavioral strategies to control movement. The CNS organizes information from sensory receptors throughout the body before it can determine the position of the body in space. Peripheral information from the visual, somatosensitive (proprioceptive, cutaneous and articular receptors) and vestibular systems is usually available to detect the movement and position of the body in space in relation to gravity and the environment [12]. Each sense provides the CNS specific information about body position and movement; thus each provides a different reference structure for postural control [11]. The CNS then plans the timing and intensity of the action, reacting against disturbances that cause imbalance, and predicts these disturbances in order to act before they happen [16].

Postural control is responsible for organizing multiple sensory information into sensory strategies for orientation. This process involves the hierarchical ordering of sensory reference structures, thus ensuring that the most appropriate sense is selected according to the environment and task [17-19]. Postural adjustments are also activated prior to voluntary movement to minimize the potential balance disturbances that movement may cause. This is called anticipatory postural control. Although we often consider anticipatory adjustments in terms of activation of postural muscles prior to skillful movement, we also use anticipation when we classify the amplitude of postural adjustments for balance disorders. The amplitude of the muscular response is associated with our expectation of the size or amplitude of the expected disturbance [15].

Postural Control Development

In the early years the child develops a vast repertoire of skills, learning to crawl, walk and run without help, achieves hand-eye coordination and object manipulation in various ways. The emergence of all these skills requires the maturation of postural activity in order to sustain the primary movement. Thus postural control is an essential part of motor development [12]. The development of postural control has traditionally been associated with a predictable sequence of behaviors called motor landmarks that are dragging, sitting, crawling, standing and walking. Control begins in the cephalic segment and occurs in the cephalocaudal direction from proximal to distal within the segments [15, 20].

Child development theories attempt to report the basis of the postural control development in this predictable sequence of motor behaviors. In reflex-hierarchical theory, postural control would start by being dependent on a reflex-based control, in which the appearance/disappearance of certain postural reflexes would reflect the maturational evolution of cortical and subcortical structures, which would have the ability to inhibit and integrating lower-level reflexes to trigger more functional voluntary and postural motor responses. Recent theories, such as systems, ecologic and dynamic action theories suggest that postural control arises from a complex interaction of the nervous and musculoskeletal systems, which is named as postural control system. The organization of the components of the postural control system is determined by both the task and the environment. Systems theory does not deny the existence of reflexes but only considers them as one of the integral elements in posture and movement control. In many ways both models are consistent; Their differences include the following factors: (1) The hierarchical reflex model considers postural control from a reaction perspective, while systems emphasizes the importance of the proactive, reactive, and adaptive aspects of the system, (2) The hierarchical reflex model gives more importance to the function of CNS maturation than to experience, whereas systems does not emphasize the function of either [21].

When babies begin to sit without support, they learn to coordinate the sensorimotor information associated with the head and upper body segments, extending to the upper body muscles the sensorimotor rules about head postural control. Thus, the emergence of the independent sitting position is characterized by the baby's ability to sufficiently control spontaneous inclination to remain erect; This occurs approximately between 6 and 8 months of age [12].

At an early age, postural activity is characterized by a large variation in specific direction of postural patterns; between 3 and 6 months postural activity may adapt to a minimum extent only in certain situations. From 6 months onwards, infants develop the ability to select which repertoire of directionally specific adjustment will be activated. This selection occurs by experience, gained by trial and error. Six months, the transitional age, is also the age at which infants usually acquire independent sitting, which means that sitting is not dependent on the ability to adapt to postural activity. The only requirement for the development of independent sitting is the ability to generate direction-specific postural adjustments [12, 22].

A study using electromyography (EMG) to record neck and upper body postural muscle responses of babies sitting on a moving platform showed that moving the platform forward and backward caused a disturbance in the baby's head and upper body posture, requiring a subsequent compensation adjustment to regain balance. The study also showed that at two months of age babies did not show consistent responses; at four months they exhibited directionally specific upper body muscle responses 50% of the time, and at eight months, when they already dominated the independent sitting position, they showed effective patterns for controlling forward and backward inclination from this position [15].

Cerebral Palsy

Cerebral palsy is a term used to refer to a heterogeneous group of non-progressive syndromes of postural and motor dysfunction characterized by brain injury occurring in the pre, peri or post-natal periods. It can be defined as a movement and posture disorder due to an immature brain defect or injury, however, it is often accompanied by other disorders such as muscle weakness, spasticity and incoordination; which, can cause daily functional difficulties and often have profound effects on the daily lives of children and their families [23-25].

Currently, it is estimated in developed countries an incidence of children with CP between 1/2 per 1000 live births [26-27]. In Brazil there are no accurate statistical data, it is estimated that for every 1000 children born, seven have CP. In developing countries, this number may be related to gestational problems, poor maternal and child nutrition conditions with often inadequate medical and hospital care [28].

The most common etiology is neonatal asphyxia, followed by prematurity and CNS infections. Maternal factors such as previous abortions, family history of neurological malformations and diabetes, as well as multiple pregnancy, attempted abortion, preeclampsia, bleeding during pregnancy, fetal malnutrition (SGA), congenital infection and abnormal fetal presentation are predisposing factors in the prenatal period. Premature detachment of the placenta, hypoxic-ischemic (acute) lesions; prematurity, difficulty breathing are prenatal factors. Cranioencephalic injuries, meningitis and encephalitis, accidental anoxia (drowning, aspiration) represents the most prevalent postnatal factors [23, 29].

The dysfunction results from lesions of different areas of the developing CNS. Each part gives rise to a variability of clinical findings, including spasticity, uncoordinated movements, muscle weakness, ataxia, and stiffness. The more extensive the injury, the more severe the child's motor condition [30]. Clinical manifestations resulting from neurological damage depend on the extent, type of CNS damage, site of injury, and CNS ability to adapt or reorganize after damage [29].

It can be classified according to motor involvement, lesion topography and severity of injury. As for motor involvement it can be: (a) Spasticity which corresponds to an increase in passive motion resistance. It is present in the pyramidal tract, usually in the motor cortex (pre-central gyrus). In addition to spasticity, hyperreflexia, clonus, and Babinski are other pyramidal signs. It is the most frequent type of CP, and children with this condition may develop some joint deformities; (b) Involuntary movements, in which involuntary motor activity, accentuated by emotional stress, occurs in lesions of the base nuclei, areas responsible for posture control and coordinated movement; (c) Stiffness, in which movement disorder is also due to damage to the base nuclei, leading to severe hypertonia secondary to muscle contraction of agonists and antagonists simultaneously; (d) Ataxia: It is mainly characterized by typical broad-based gait secondary to lack of balance. It is related to cerebellar tract lesions; (e) Hypotonia is usually accompanied by hyporeflexia, is quite rare in CP and corresponds to a decrease in resistance to passive movements. Usually later in life the child will have choreoathetosis, ataxia or in some cases spasticity; (f) It is the mixed consisting of the combination of two or more movement changes [24, 31].

Regarding the classification based on topography, the clinical patterns described in CP include: extra-pyramidal type, comprising athetosis, ataxia and mixed; and pyramidal type, including monoplegia (single-limb involvement), diplegia (significant lower limb involvement with little effect on upper limbs); hemiplegia (ipsilateral involvement of upper and lower limbs); and quadriplegia (involvement of the four limbs) and triplegia (rare condition in which three limbs are affected) [29].

Regarding severity, the classification is subjective and depends on the observer's perception, in which the most relevant aspect is the degree of motor involvement: (a) Mild: characterized only by fine movement changes; (b) Moderate: variable difficulty with speech and rough movements, but activities of daily living are performed without major problems; (c) Serious where the child shows inability to walk, perform activities of daily living and difficulty in communication and oral language [32].

Regarding functionality CP has been classified through several functional scales. GMFCS has been used internationally to classify patients with CP. The scale ranks into five levels based on functional mobility or activity limitation where a child classified at Level I has less gross motor dysfunction, whereas the child at Level V exhibits limited voluntary movement control [24]. The GMFCS classification offers the possibility of creating a homogeneous functional representation within the heterogeneous group of children with CP [12].

Although characterized by the motor problem, CP is always accompanied by other disorders of brain function, such as cognitive, visual, auditory, language, sensorial, behavioral deficit among others. Those may evolve with seizures as well as perceptive and visomotor disorders, sleep disorders, oral and dental problems, growth disorders and orthopedic deformities [7]. Inactivity can lead to decreased bone density leading to fractures [29]. Depending on the motor condition and early treatment, those are subject to various deformities such as hip dislocation, kyphosis, scoliosis, equine valgus or varus foot and muscle contractures. Hip dislocation is one of the main deformities because if not properly treated can cause severe pain. In addition to pain, it causes difficulties in the ability to sit independently (see Figure 1), as well as hygiene itself and also contributes to the onset of scoliosis [32].

Figure 1. Patient with spastic diplegia type CP showing a dextrous convex scoliosis, which impairs independent sitting as well as handling and range.

All these motor changes have an important impact on the daily activities of children with CP because they can affect tasks such as dressing, eating, bathing and attending school.

Postural Control of Children with CP

Postural control is a prerequisite for performing daily life activities [6, 19]. Postural control deficit is one of the main problems faced by children with CP. The performance of daily life activities are influenced by postural deficit, which varies with the severity of the dysfunction [33]. There are also biomechanical deficiencies, such as the size of the support base, which also influence posture control. The small base of support in the standing posture induces a greater postural deficiency when compared to the deficit in the sitting position, which offers greater stability. Thus, in order to perform their daily life activities properly, many children choose to remain seated most of the time [19, 34-35].

The most frequently occurring dysfunctions in children with CP are related to the adaptation of postural muscles. This implies a refinement of the basic adjustments to environmental conditions based on one's own sensory, visual and vestibular system experiences and inputs [21, 36-37]. Postural control problems in children with CP are basically due to the following factors: (a) defect in motor unit recruitment (stereotyped muscle recruitment), (b) abnormal muscle recruitment dependent on spasticity, (c) non-selective activation of antagonist muscles, (d) immature motor programming interference, and (e) changes in the mechanical properties of muscles [13].

Stereotypical muscle recruitment is observed when there are contractions of several muscles at the same time, generating an uncoordinated block motion, which is also generated in a cerebrospinal order, similar to those found in infants between 3 and 6 months of age [1, 19, 36]. This generates an immature and poor handling programming.

Preference for recruitment of the cerebrospinal postural musculature (top to bottom) occurs not only during sitting and standing disturbance experiments, but also during sitting reaching movements [1, 19, 37]. Brain-caudal recruitment involves early activation of the neck extensor muscles before activation of the upper body and hip muscles. This activation in is present in infants from 3 to 6 months of age when there is a risk of loss of balance. But when sitting independently, this reverses and babies have a preference for bottom-up recruitment in the caudal-cephalic sense. The fact that this strategy occurs more often in mild and moderate CP children than in severe children could indicate that the preference for cerebrospinal recruitment reflects in a child's strategy to deal with poor postural control [8].

Co-activation of antagonist muscles occurs when there is non-selective muscle activation of antagonist muscles that should oppose agonist contraction to perform a movement. It can be observed during stable postural control but also in experiments that perform surface disturbance in sitting and standing position [1, 4]. In the sitting position, co-activation is especially high during backward body-induced disturbances. During disturbances that induce forward body sway, few antagonistic contractions are encountered. This is related to greater stability in this situation induced by seated body biomechanics and greater experience with forward body oscillations, as it is often used in everyday activities such as reach [1, 37-38]. Therefore, non-selective contraction of antagonist muscles leads to a difficulty in postural maintenance especially in the face of disturbances. Factors such as spasticity, muscle weakness, musculoskeletal disorders, stereotyped activation of the extensor musculature, imbalance between agonist/antagonist muscle activity and abnormal muscle recruitment common to children with CP make postural control in these children extremely impaired. Physical therapy methods aimed at sitting postural control need to be directed to patients in order to improve both the range of abilities to perform daily living activities and their quality of life [39].

Treatment CP- Postural Control

Over time the most appropriate physical therapy treatment for children with CP has been one of the main topics of study. There are numerous methods used in physical therapy to treat children with CP. Each has specific goals for each patient, motor condition, age and prognosis. Traditionally, physiotherapeutic treatment in neuropediatrics is based on the Bobath Neuroevolutionary Method currently used as a synonym for NDT (Neuro-Developmental Treatment) [40]. The Bobath NDT/Approach was developed by Berta and Karel Bobath in 1943 from clinical experiments, based on motor control and neuroscience models available at the time. It is used to treat individuals with movement dysfunction resulting from CNS injuries mainly for children with CP. NDT is an interactive process that includes the patient, their family, and an interdisciplinary team from assessment to treatment [41]. The overall goal of treatment is to increase an individual's ability for functionality. It is holistic, involving the patient addressing not only his sensorimotor problem, but also developmental problems, perceptual-cognitive and emotional impairments, as well as the functions of daily living [31, 42]. The intervention basically includes the inhibition of pathological reflexes and the facilitation of new functional acquisitions [38]. The Method works with movement facilitation, i.e., automatic posture adjustments are required to produce automatic protection, straightening and balance reactions [39, 40-41].

However, this method has been questioned as to its success in achieving better postural control [8, 10]. Although it has been used in many countries for over 60 years, it is a method that is both repetitive and discouraging for children, who see it as a trial and also for their parents who, in the face of slow results, feel unmotivated in giving continuation of a treatment in which it is quite prolonged.

Equine therapy is also widely used to treat postural control deficit in patients with neurological disorders. It is a therapeutic method that uses the horse within an interdisciplinary approach, seeking the biopsychosocial development of people with special needs [43]. This treatment has been widely used to improve children's sitting postural control where it provides improved pelvic and hip movement, trunk, head and balance in response to horse gait [44-45].

The horse's center of gravity is shifted during walking in a three-dimensional model, which is similar to the action of the human pelvis during gait. The movement of the horse causes balancing and rectifying reactions. The facilitation of these reactions contributes to the necessary basis for normal and functional movements [43].

In Brazil, there are several hippotherapy centers that offer treatment to children with CP. However, several factors make it difficult and even unfeasible to practice such as: adverse weather conditions; difficult access to riding centers, usually located in distant areas; the need to use properly trained animals; expensive therapeutic care due to the high cost of maintaining the centers (caretakers and food); frequent rejection by the child for fear of the animal; possibility of allergic reactions due to the environment and difficulty in continuing treatment for long periods as well as subjectivity in the evaluation of possible benefits.

A comparative study between equine therapy and TDN showed that there was a significant improvement in the group of children undergoing equine therapy [46]. Studies evaluating the effects of hippotherapy in children with CP have concluded that the movement provided by the horse increased pelvic mobilization, normalized tone, developed upper body control, balance and postural reactions in treated children [44-47].

However, it is often not available to most patients due to limited access to horses, high cost, among others [48]. There are, however, other features that can be used with effects similar to hippotherapy. In the 1990s artificial mechanical saddles were designed to recreate the horse's movements during a riding session and some studies have shown benefits in treating children with CP [5, 48]. They were successfully used in treatment showing decreased spasticity, greater stability in sitting position, improved postural adjustments in unstable situations and faster muscle recruitment. However, they gradually ceased to be used, probably because they are heavy and relatively impractical devices.

Still in the 90's were developed in Japan by (Matsushita Panasonic Electric Works, ltd., Japan), therapeutic riding simulator equipment designed to provide a home riding system. The first model was created in 1993 as a horse-robot being modified and refined over the years. The most recent model (2007) Joba® has movements identical to those produced by the horse during riding.

The equipment has six movements: (1) rotation movement; (2) back and forth movement; (3) right and left movement; (4) up and down movement; (5) forward diagonal movement; (6) backward diagonal movement [49, 50]. Among the manufacturer's indications are: physical inactivity, obesity, low cardiorespiratory resistance, low back pain and inactivity caused by senility.

The physiological effects of the simulator are basically the same as riding. It promotes through movement, postural adjustments where specific muscle groups are activated to maintain the posture against gravity. These repeated adjustments cause muscle strengthening mainly of the pelvic, abdominal and lumbar muscles [49-51].

PURPOSE

The aim of the present study was to quantify the effects of a therapeutic riding simulator on the postural control in the sitting position of children with spastic diplegia CP; where maximal displacements in the anteroposterior (AP) and mid-lateral directions (ML) by FScan/FMat system; functionality classification by GMFCS as well as patients' satisfaction with treatment through the AUQEI scale) were evaluated.

METHODOLOGY

Study Profile

Randomized clinical trial conducted between February and December 2008 at the Physiotherapy School Clinic and at the Biomechanics Laboratory of the Catholic University of Brasilia (UCB) Brazil.

Ethical Considerations

The experimental protocol of the study was approved by the UCB Research Ethics Committee. After clarification about the study, all parents or guardians signed an informed consent form.

Sample Compositions

The study included 40 children with spastic diplegia CP, randomly assigned to two groups: The group using the simulator (SG) was composed of 20 children (eight boys and 12 girls) with a mean age of 5.65 ± 2. 48 years (median = 5) and the conventional group (CG) composed of 20 children (nine boys and 11 girls) with a mean age of 5.77 ± 2.29 years (median = 5).

Selection of Individuals

Inclusion Criteria

All children with CP classified as spastic diplegia attended at the UCB Physiotherapy School Clinic, in the morning and afternoon, besides those on the waiting list were invited to participate in the present study, which totaled 50 children. Of these, 7 children met the exclusion criteria, so 42 were randomly drawn (by the Biomechanics Laboratory technician) with the distribution of even and odd numbers to the guardians. Those who received even numbers comprised the simulator group (GS) sample and those that received odd numbers were allocated to the conventional group (GC). At the end of the study two children moved from town without completing the proposed evaluations. Thus the study was completed with 40 children.

Exclusion Criteria

Children who could not understand the study protocol, who had hip and/or spine deformity, who underwent surgery or medication to reduce spasticity in the last six months and who refused to follow the protocol were excluded. In total, seven children.

Procedures

Before and after the intervention period, all children had their postural control measured by the body oscillation record (FScan/FMat System) and also evaluated by the Gross Motor Function Classification System (GMFCS), designed to rank each child's level of gross motor function. The classification is made by the determination of the five best levels, where a child classified in level I presents less gross motor dysfunction, whereas the child in level V exhibits limited voluntary control of movement. This rating scale is based on the child's own movement initiative with an emphasis on walking and sitting ability, with or without the use of assistive technology such as walkers, crutches, wheelchairs. For each level, separate descriptions are provided for children in the age groups: under 2 years, 2 to 4 years, 4-6 years, 6-12 years [52].

At the end of the study, all children responded to the AUQEI (Autoquestionnaire Qualité de Vie Enfant Imagé) scale, a quality of life assessment scale capable of assessing the child's subjective sense of well-being [53]. Validated in Brazil [54] it is composed of 26 items related to the domains activity, health, function and separation; totaling 78 points. It is answered by the child himself, using a support of face images showing different emotional states: very unhappy, unhappy, happy and very happy. Each face gets a score from 0 to three respectively. The cut-off value is 48, and values above indicate good quality of life, and values below predict the opposite [53]. Was added 14 questions to the questionnaire [55], addressing aspects of motor disability and the rehabilitation process, which are not included in the original questionnaire. In the present study we chose to use the original scale, only adding question 3 ("How do you feel in physiotherapy") by the author.

The assessment of body oscillations in the anteroposterior (AP) and mid-lateral (ML) directions was performed by recording the maximum displacement of the pressure center (PC) according to the protocol [56]; using the F-Scan system with software version 4.21 and F-Mat model 3100 platform sensor (Tekscan, Inc., South Boston, MA) (Figure 2) and calibrated before each recording following the proposed method by the manufacturer.

The force platform consists of a plate under which some load cell or piezoelectric force sensors are arranged to measure the three force components, Fx, Fy and Fz (x, y and z are the anteroposterior, midline, lateral and vertical respectively). This equipment records the vertical force exerted under the individual's foot at each point in a resistive network of overlapping rows and columns. It shows in real time the PC (Figure 3), its displacement displayed in image, graphical and/or numerical form.

Figure 2. FScan/FMat system.

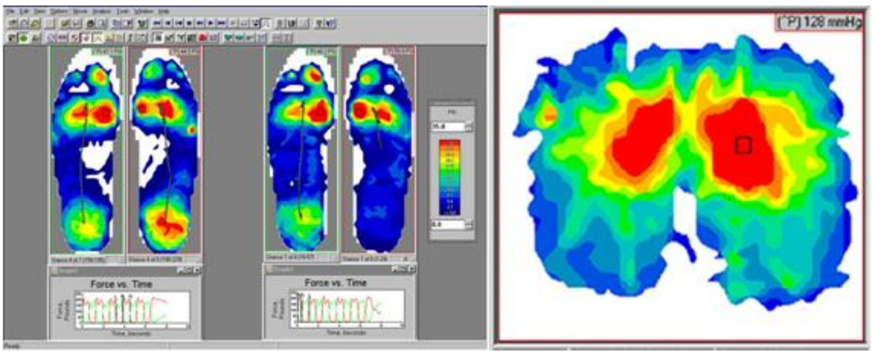


Figure 3. Image captured by platform with patient standing and sitting showing PC in red.

The CP can be determined by the row and column coordinates of the system sensor. Knowing the distance between each row or adjacent column it is possible to calculate the distances between the points, determining the displacement of the PC. Digital data is arranged and transmitted via a coaxial cable to the rest of the circuits, located on a board in a computer. This receiver handles data from the pressure unit and places it in computer memory [57-58].

Data obtained from an assessment of plantar pressure can be used by the physiotherapist to evaluate and manage adult and pediatric patients with a wide of variety of foot and lower extremity diseases associated with neurological disorders and musculoskeletal system. These systems provide the clinician or researcher with important information about the forces and pressures applied to specific foot sites and the effects of various interventions, including the use of footwear (tailor-made for diabetic ulcer sufferers), athletic footwear, and the working population, use of foot orthoses as well as gait training and surgical treatment [58-60]. Studies show that the use of platform and sensor systems while sitting are useful for prescribing wheelchair seats to prevent decubitus ulcers as well as evaluations of sitting postural control for both balance analysis and PC displacement [35, 56, 61-62].

For the present study the platform was positioned on a bench (Figure 4) to accommodate the sitting child and wooden blocks were used to support the children's feet so that they remained as comfortable as possible while maintaining their hips and knees. with 90º of flexion.

Figure 4. Children's standard positioning for data collection.

Each collection lasted one minute with a sampling frequency of 100 Hz during which the child sitting on the platform was instructed to cross his arms as if to hug their own body and move their body forward, back, left and right as much as possible. No intervention was performed by the therapist while performing the test. Three collections were performed to obtain an average value in signal processing. The data obtained from the F-Scan system were filtered by the Butterworth digital filter of the fourth order with a 5 Hz cutoff frequency using Labview software version 5.0 and exported to calculate the maximum center of pressure displacements in the AP and ML directions using the Excel spreadsheet.

Figure 5. Joba® therapeutic riding simulator.

Figure 6. Joba® was covered by a (Kidtoys®) stuffed horse, thus providing a more playful look to the equipment (Figure 6).

For the intervention, SG children underwent 12 treatment sessions on the Joba® riding simulator (Model EU6310); (Figure 5) using equipment level 1 and with frequency of 100 Hz and two weekly sessions, as well as the work [63], where each session lasted 40 minutes.

The CG children underwent 12 conventional treatment sessions based on the NDT Method (Figure 7) emphasizing specific trunk control techniques and two weekly sessions lasting 40 minutes each. All children were attended by a single professional, experienced and certified by the Method.

Figure 7. Patient under care by NDT Method.

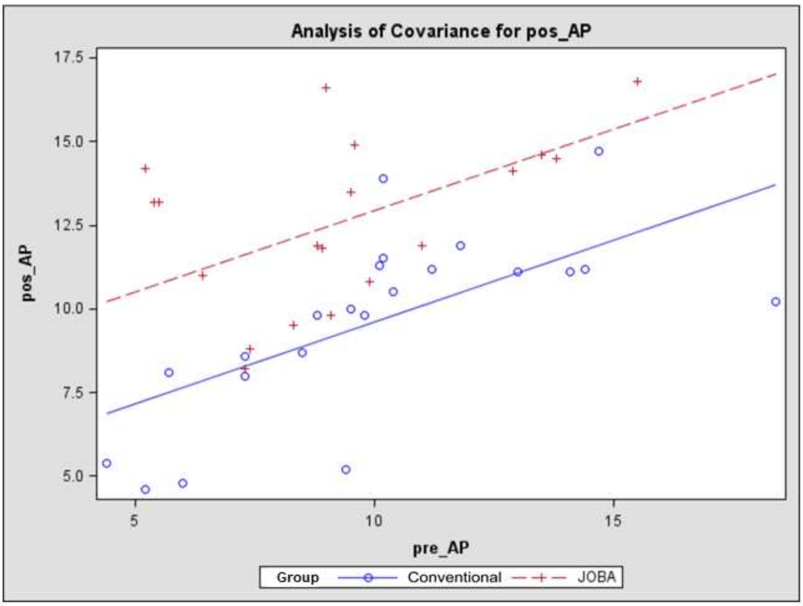
Statistical Analysis

For the statistical analysis of the maximum displacement in AP and ML we used a parametric covariance analysis model (ANCOVA), which aims to test if there is significant difference between the two groups, taking into account the measurements obtained before the intervention.

Parametric ANCOVA assumptions were tested and all satisfied among them: normal and independently distributed errors; homogeneous intra-group regression coefficient and linear relationship between pre and post test values. A proportional probability model with generalized estimation equations [64] (GEE) was used for the GMFCS variable; and to compare the degree of satisfaction (AUQEI scale) between the two groups, the Mantel Haenszel chi-square test was used. For analysis purposes, a significance level of 5% was used.

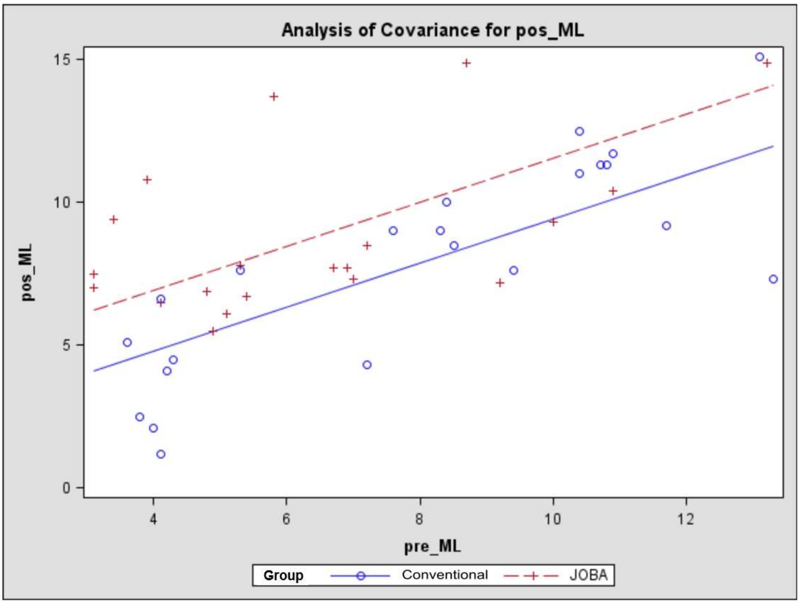
RESULTS

Parametric covariance analysis of the anterior-posterior (AP) and mid-lateral (ML) pressure center displacement amplitude of children in both groups (Simulator and Conventional) before and after treatment can be viewed individually in the graphs 1 and 2.



Graph 1. AP covariance analysis of the Simulator and Conventional groups.

Graph 1 shows the individual variations of AP measurements in the pretest and posttest. It is observed that the children of the simulator group showed, for the most part, a greater anteroposterior displacement than the children of the Conventional group.

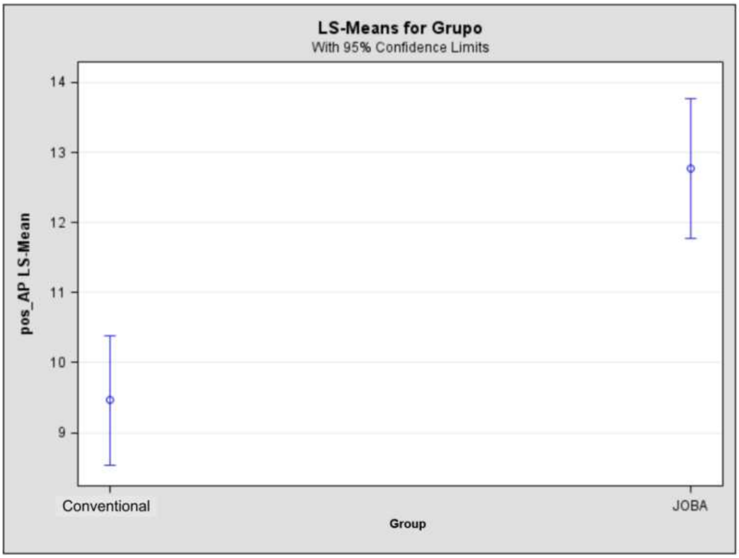


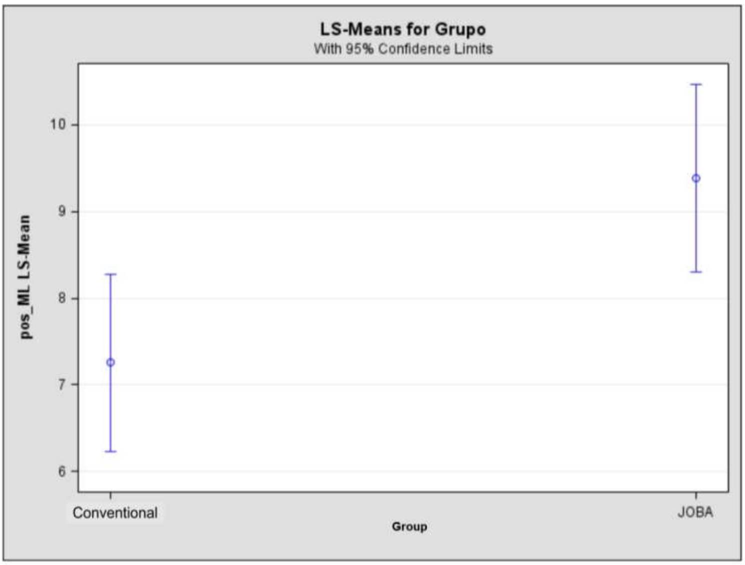
Graph 2. Analysis of covariance in ML of Simulator and Conventional groups.

Graph 2 shows the individual variations of the ML measurements in the pretest and posttest. As in the maximum displacement in AP, the measurements in ML were mostly higher in the Simulator group than in the Conventional group.

Graph 3 shows the overall mean between the two groups before and after treatment. As observed individually, this graph shows that the group of children submitted to the simulator had higher maximal displacement values both in the anteroposterior and in the mid-lateral directions.

Taking into account the pretest AP measurements in both groups, the mean in the Simulator group was statistically higher than the average in the Conventional group (P <0.0001). The same happened in ML displacement where the Simulator group was statistically higher than the average in the Conventional group ($P = 0.0069$).





Graph 3. Overall average of the Simulator and Conventional groups in AP and ML.

When children were classified by the GMFCS it was found that there were no children at level I; eight were at level II; sixteen at level III; fourteen at level IV and two at level V at the beginning of treatment. GMFCS was used to classify children according to functionality, however it was observed after the intervention that some children showed important functional acquisitions. It was then obtained by applying the scale again after the intervention. A change of level was then observed in five children from GS and two children from CG.

Statistical analysis also showed that children treated by the simulator are 1.63 times more likely to have a lower score after treatment than before treatment (p = 0.0110); Similarly children treated by the conventional method are 1.22 times more likely to have a lower score after treatment than before treatment, however this change was not statistically significant (p = 0.1510).

The application of the AUQEI scale showed that they are happy children with high satisfaction response profile where the overall score was 58 showing a good quality of life. Regarding the physiotherapeutic treatment, the statistical analysis showed that the simulator provides more satisfactory results than the conventional method (p = 0.0026).

The proportion of children who were very happy with the simulator is much higher than the proportion of children who were very happy with the conventional method. On the other hand, no child was unhappy with the simulator while five children were unhappy with the conventional treatment.

Discussion

The present study quantified the effects of a riding simulator on postural control in the sitting position of children with CP where a statistically significant improvement in maximal dislocations in the AP and ML directions was evident in the group treated with the simulator when compared to the conventional group. This increase in maximum displacement resulted in the child's family members' perception of a significant improvement in the performance of daily living activities that required greater mobility and postural control, as well as improved posture maintenance, greater pelvic mobility, improved independence for eating, swallowing, eating and sleeping.

In the present study, the PC displacement in AP was slightly higher than in ML. Usually the displacement in AP is greater than the ML displacement because it is widely used for manual reach during daily activities [1]. In addition, the rounded shape of the sciatic tuberosity induces a pelvic movement in the AP direction allowing greater displacement than in ML, and the contact area being larger due to the length of the thighs [56]. A similar study showed that children with CP treated in an artificial mechanical saddle had improved postural stability at maximal dislocations in the AP and ML directions, with the AP being higher in both treated groups [48].

Seated postural control has been assessed using Posturography, which is the technique used to measure body sway or a variable associated with body sway. The most commonly used Posturographic measurement in the evaluation of postural control is the PC; and the most used equipment to measure the PC is the force platform. A study demonstrates that platforms have been a good alternative with high reliability to assess PC, both dislocation and stability in sitting patients [56]. In the present study, the FScan/FMat system proved to be effective for measuring PC displacement in the studied population. Posturographic evaluation is commonly divided into static when the patient's quiet upright posture is studied and dynamic when studying the response to an applied disorder [65-66].

Studies have compared the open-eyed and closed-eyed PC trajectory of children with CP and typically developing children sitting under a force platform; concluding that children with CP exhibit greater oscillation (static posturography) compared with typically developing children [65, 67-69]. Studies have evaluated sitting postural control, specifically static and dynamic sagittal (AP) and lateral (ML) balance, comparing children with CP and typically developing children, using a pressure platform to measure maximal displacement of the center of pressure (dynamic posturography). Children with diplegic CP showed significantly worse sitting postural control compared with normal children of similar chronological age [34-35].

Regarding static sitting posture, there is much discussion about which position is considered ideal for children with CP. There are those who stand for upright sitting, others for reclining. The ideal is to find a position that allows the child to control his arms and head in an ideal way for food, clothing and communication [19].

Figure 8. Child with spastic diplegia type CP sitting with pelvic retroversion making sitting posture without support difficult.

The sitting posture before the onset of reach of children with CP differs from children with typical development, especially in diplegic children: they sit with a more reclined pelvis and a more collapsed trunk. This may be partly attributed to the instability of weak flexor muscles and extensor overactivity. In addition, it can be explained by the strategy of dealing with postural instability. Since in the sitting position with pelvic retroversion (see Figure 8), children with diplegia are better able to adapt postural muscle activity to environmental conditions than when seated with the less retroverted pelvis [6]. Thus children with CP, especially the diplomatic ones, seek to sit in these compensatory positions in order to utilize the upper limbs in daily activities that are proposed to or of interest to them.

The sitting position generates a higher limit of stability, regardless of the position of the seat or legs, because when one or the other changes, the child generates compensatory responses of co-contraction, or even inclination of the trunk forward, allowing a greater degree of freedom. to perform a task. Sometimes the retroverted posture of the pelvis and often lumbar kyphosis does not prevent range movement, as some children adapt over time and incorporate the image of that movement [19]. The fact is that an ideal seat structure improves postural control translating into a greater repertoire of functional skills for the upper limbs [62]. However, allowing the child to remain in a static sitting posture for long periods risks deformities and therefore limits more functional movement and acquisition. Over time they will become increasingly dependent on her family even for activities they had already acquired the ability to perform.

Regarding dynamic sitting posture, it is known that pelvic movement in children with CP may be limited by spasticity or increased tone in specific muscles. Pelvic position and movement are extremely important in the postural control of children with CP; because they influence the alignment of the spine, head and limbs, facilitating or hindering postural alignment for balance and reach. Children with CP have little pelvic movement; some may increase anterior inclination by performing lumbar hyper lordosis, others may increase posterior inclination resulting in kyphosis making movement difficult in this posture [70].

Studies have investigated the pelvic mobility of children with CP sitting in an artificial mechanical saddle (BABS) and a static saddle, concluding that children who were treated in BABS had a significant increase in pelvic movement compared to those who were treated in static saddle. The same authors stated that when children improve pelvic mobility, they also improve postural alignment, upper limb function, and reduce the risk of deformities [5, 48, 71]. Thus, a treatment that provides adequate pelvic alignment; as proposed by the simulator, can contribute to better postural control for activities such as handling and reach.

Working with the child in hip abduction can contribute to the reduction in neural components that trigger spasticity thus allowing for increased pelvic movement. The greater the movement of the pelvis, the greater will be the displacement of the PC. Biomechanically, the hip abduction position promotes passive stretching in the often shortened adductor muscles; which further contributes to pelvic mobility [5].

In the present study, it was observed that in the riding position (hip abduction) (see Figure 9) the simulator promoted greater pelvic alignment and greater mobility, which contributed to the better result of the group treated with the simulator.

Figure 9. Child with hip abduction spastic diplegia mounted on the simulator.

In addition to hip abduction positioning, the sensory stimulus provided by simulator movement is paramount to provide the CNS with the ability to use previous experience to refine similar movements in the future. The child during the movement performs pelvic dislocations in various directions, rolling under the sciatic tuberosities, pelvic elevation and depression, anterior and posterior tilt which repeatedly will lead to greater mobility also to learning movement [48].

Agonist and antagonist activity is known to be reduced in children with CP. Rhythmic movement may inhibit abnormal co-contraction of the pelvic muscles, facilitating more selective control. This is because movement causes increased demands on the body which can facilitate weaker muscles to contract and inhibit more active muscles from being activated, thus causing greater balance [5, 48]. The simulator provides six movements (rotation, back and forth, right and left, up and down, diagonal forward and diagonal backward) and three program levels to choose from the therapist or patient. The results of the present study suggest that the movement provided by the simulator was largely responsible for the success of therapy in the simulator group.

We therefore consider it of utmost importance to rethink the physical therapy treatment for children with CP, without abandoning the traditional treatment, but introducing proven technological innovations that provide more dynamic approaches to physical activity protocols. The association of an attractive activity that provides functional gains results in the child's acceptance of treatment, ensuring their spontaneous and fun participation [10]. Studies suggest a form of physical therapy treatment for children with CP based on motor strategies that facilitate and optimize restoration of function; treatments according to the child's preference but ensuring their active participation [72-73].

The choice of riding simulator as a form of physical therapy treatment is not only due to its extremely motivating component, but also for the following advantages: it can be used anywhere (office, clinic), or even in the patient's own home; independent of weather conditions; It is relatively small, quiet and children enjoy to use it; It is easy to use with specific programs and can measure exactly the time and movements chosen; besides allowing to increase the degree of difficulty of the patient gradually.

The simulator has been used in muscle strengthening programs with the elderly demonstrating increased muscle strength and contraction [49, 50, 63, 74]. Its use has been described in children with a protocol similar to the present study, however its results have not yet been evaluated [75]. By faithfully reproducing the horse's movements, the physiological effects of the simulator are basically the same as riding without its disadvantages. It promotes, through movement, postural adjustments that will activate specific muscle groups to maintain the posture against gravity. The repetition of these adjustments will therefore cause muscle strengthening mainly of the pelvic, abdominal, and lumbar muscles thus improving trunk balance and postural control against gravity [49, 50, 63, 74]. The results of the present research suggest that when children began to perform greater recruitment and muscle strengthening, there was increased pelvic mobility, better sensory perception and consequently better sitting postural control.

Psychological factors may also contribute to the greater success of treatment with the simulator. Factors such as fear and insecurity can cause increased tone and make all work unfeasible. In contrast, an interesting and entertaining treatment causes greater acceptance and participation in therapy [35]. Conventional treatment was based on TDN, a method that has traditionally been used to treat children with CP. However, authors suggest that this more traditional form of intervention is not effective for improving postural development [8]. In the present study, it was observed that the children of the CG presented improvements, but less significant than the children submitted to the simulator.

In the present study, the gains were evident not only from better sitting postural control, but also from the change in GMFCS level that is generally cited by the scale authors as extremely difficult to obtain due to the fact that it is not a measurement scale of the GMFCS functional level [52]. There are better instruments for measuring functional gains, such as, for example, GMFM [76]. In the present study, GMFCS was used to classify children and not to evaluate functional gains. However, to the researchers' surprise, seven children (five from the SG and two from the CG) achieved such significant gains that they were rated after the study at levels different from those previously rated. Of these, three began to sit independently, two started using Canadian crutches and two acquired independent walking. Thus, in addition to the gains in postural control in sitting position, the children obtained greater independence in their daily activities, which is important and stimulating not only for patients, but also for their families and therapists.

Despite all the deprivations, what was noticed during the application of the AUQEI scale is that they are happy children with high satisfaction response profile for vacation, birthday, grandparent and sports items and similarly low scores for hospitalization and being away from family as mentioned by authors [52]. However, when asked separately about physical therapy, the children of the CG were less happy than the children of the GS.

Willingness, enthusiasm and joy are essential in working with PC children [46]. In the present study, treatment with the riding simulator provided the children with an extremely fun activity, which allowed them to be bolder each day. The more they participate in the more interesting treatment the experience became. Anyway, all the gains were for the children of joy and for the extremely significant parents. Thus, the equipment is currently available to all patients at the UCB Physiotherapy School Clinic.

CONCLUSION

The use of the riding simulator was statistically superior to conventional physiotherapeutic treatment in all aspects: postural control in the sitting position (evidenced by the significant increase of the maximum displacement in the AP and ML directions through the FScan system), in the global functionality (proven GMFCS) and children's quality of life and satisfaction (visualized through the AUQEI scale) and additionally associated with the great satisfaction of family members with the therapeutic procedure.

However, this study also has limitations such as the data quantification. It is important to develop other studies, measuring the use of the simulator in other populations and pathological conditions, as well as studies whose treatments provide functionality, active participation, joy and quality of life for children with CP.

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Chapter 3

EVALUATION OF POSTURAL STABILITY IN CHILDREN WITH VARIOUS FORMS OF CEREBRAL PALSY USING STABILOMETRIC PLATFORM

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ABSTRACT

Background

This prospective clinical study deals with evaluation of postural stability in children with various forms of cerebral palsy. Deficit in postural stability often correlates with limited ability to perform common daily life activities. One of the methods of intervention in cerebral palsy is the Acral Coactivation Therapy. In this method motor patterns are practiced within common everyday activities in patients' real conditions.

Objective

The study deals with evaluation of postural stability in children with cerebral palsy. The goal is to evaluate and to compare the influence of the Acral Coactivation Therapy and other individual movement therapies without method intervention.

Methodology

The pilot study took place in spa environment in the children rehabilitation department. Twenty-four children took part in the evaluation held from February to September 2015. All participants were randomly divided into two groups. The average age in the trial group with intervention methods was 10.25 + -4.6 years and 8.17 + -3.9 years in the control group. Postural stability was measured on Alfa stabilometric platform. The aim was to compare difference in the resulting values of load distribution in anterio-posterior direction and in medio-lateral direction. The evaluation was carried out regularly at the beginning and at the end of 3-week therapy sessions.

Results

The biggest difference between the groups was in parameters of load distribution in anterio-posterior position. The standard deviation (Cohen's d) was d = 0.8 in outcome values. In the parameters of load distribution in medio-lateral position the standard deviation was $d = 0.5$.

Conclusion

The benefit of the Acral Coactivation Therapy in children with cerebral palsy consists in working out in positions of motor development using support of the acral parts and the possibility to incorporate these exercises into daily life activities.

Keywords: cerebral palsy, postural stability, the Acral Coactiovation Therapy, movement patterns

INTRODUCTION

Cerebral palsy (CP) in children is a neurodevelopmental disorder of body posture and movement caused by central nervous system impairment. Children with CP have limitations in both static and dynamic postural control [1-4]. Due to this dysfunction motor skills requiring balance, such as walking, movement of upper extremities (i.e., grasping objects, activity of orofacial muscles - swallowing, speaking) are limited. These limitations impact daily life activities [5]. Woollacott [4] claims that the ability to keep balance is significant for a number of movements, such as performing functional skills, and when stability is unexpectedly lost.

The neurophysiological factors influencing postural functions include flawless multisensory integration of proprioceptive, vestibular, visual and skin information [6-13]. nervous system excitability rate, quality of feedback mechanisms regulating balance, quality of motor differentiation and associated level of relaxation skills and, last but not least, mental health impacts [11]. Biomechanical aspects of skeletal muscle system are also important for maintaining balance [14]. Association among sensory, control and executive functions in posture control is the reason of stereotype change occurring in orthopaedic, neurological and internal disorders [11].

Children with CP have difficulty in adapting the level of muscle contraction, so that is why excessive antagonistic coactivation often occurs during complex balance tasks and cranio-caudal recruitment develops during achievement of these tasks [15-16]. Both these stereotypes can be considered functional strategy for compensating non-functional strategy of postural control [15]. C. van der Heide [15] claims that antagonistic coactivation in CP is not deficit but functional adaptation during achievement of tasks with a high degree of difficulty. Cranio-caudal muscle activation, i.e., when quick activation of neck muscles and slow activation of back muscles occurs, is typical in children with a mild form of CP. Also in this case cranio-caudal muscle activation is considered functional adaptation. For that reason the therapy should not be focused on change in this functional adaptation but on balancing exercises where children exploit this adaptation [15].

Pathological phasic ability to move refers to the pathological postural basis. Targeted influence on postural functions can impact muscle tone and prevent fix contractures, which occur in children [17]. Marešová [18] also claims that if we want to change wrong up to pathological body posture, further motor programmes need to be developed. These programmes are fixed by setting a particular initial position which is adjusted to the best achievable form in collaboration with a child.

The Acral Coactivation Theraphy (ACT) is a neurophysiological method based on fixation of motor learning in the positions of motor development and its variants. Motor patterns are executed in individual positions by pressing up against the acral parts of extremities, which results in subsequent coactivation of muscle chains in extremities and the trunk [19]. The aim is to maintain and to activate functional motor functions in children and adults, not only in those suffering from cerebral palsy. During workout this neuromuscular method exploits pressing up motor patterns which are not developed or which are missing in children with cerebral palsy. By repetition of these motor patterns based on pressing up against the acral parts the spine straightens.

Postural instability in children with CP is obvious on the stabilometric platform based on oscillation of the centre of pressure (COP) in anterio-posterior (A) and medio-lateral (ML) direction. Postural stability is defined as the ability to maintain and to control the centre of body gravity within support base to prevent falling and to control a required movement [16].

Children with CP may perceive their individual limitation in a different manner and they may choose a wide support base for compensation of insufficient postural management [20].

GOAL

The goal of this study is to assess and to compare postural control in various forms of CP by means of Alfa stabilometric platform. We established two hypotheses. The Hypothesis 1 will compare the resulting values between the monitored group A and the control group B in parameters of load distribution in anterio-posterior direction (average deviation on *x* axis). The Hypothesis 2 will compare the resulting values in medio-lateral direction (average deviation on *y* axis). We will assess also the impact of the ACT method on postural stability of the monitored group A, where intervention of this method took place for the period of 3 weeks.

METHODS

Participants

The pilot prospective and intervention study took place in the department of children's rehabilitation in spa environment. Twenty-four patients (19 girls, 5 boys) took part in the study. The cohort was randomly divided into two groups: the monitored group A and the control group B (see Table 1). Postural stability was measured on Alfa stabilometric platform [21]. Load distribution was measured in anterio-posterior (average deviation on *x* axis) and medio-lateral (average deviation on *y* axis) direction. Measurement was carried out always once at the beginning and at the end of the 3-week therapy.

Table 1. Characteristics of the patients with CP – monitored group A and control group B

	monitored group A **n = 12**	**control group B** **n = 12**
average age	10.25 ± 4.6	8.17 ± 3.9
gender		
men	1 (8.3%)	4 (33.3%)
women	11 (91.7%)	8 (66.7%)
GMFCS level (n)		
I	3 (25.0%)	3 (8.3%)
II	1 (8.3%)	9 (75%)
III	5 (41.7%)	0 (0.0%)
IV	3 (25.0%)	0 (0.0%)
walking aids, adjuvatics (n)		
wheelchair	6 (50.0%)	0 (0.0%)
walker	1 (8.3%)	0 (0.0%)
crutches	1 (8.3%)	3 (8.3%)
none	4 (33.3%)	9 (75.0%)

Basic medical data was collected in patients. Children underwent kinesiological examination and according to the Gross Motor Function Classification Scale (GMFCS) they were classified into an appropriate degree (ICD – 10, International Statistical Classification of Diseases and Related Health Problems, 2016) [22]. Legal representatives were made aware of the course of the study, they agreed with anonymous data processing, they could voluntarily enter the study and they signed their informed consent.

Study Inclusion Criteria

The condition for inclusion in the study was CP diagnosis according to the International Statistical Classification of Diseases and Related Health Problems [22]: spastic quadrilepia, diplegic and hemiplegic cerebral palsy, or ataxic form of cerebral palsy. The age was between 3 and 18 years and classification by GMFCS I, II, III or IV. The diagnosis was made by a neurologist or a rehabilitation physician according to the ICD – 10 [22].

Exclusion Criteria

Children who underwent surgical and orthopaedic operations or botulinum toxin application in the last six months could not take part in the study. Children with cardiovascular or other systemic illnesses and non-collaborating patients were excluded as well.

Examination of Stabilometric Platform

For objectification of postural stability we used static posturographic examination. Input and output measurement on Alfa stabilometric platform was carried out in the patients at the beginning and at the end of the 3-week therapy. Children had to stand on the stabilometric platform barefooted, feet pelvis width apart, arms down by their side or leaning against adjuvatics (walker, crutches). For input and output measurement the position of feet was entered in the computer according to the coordinates marked in the posturograph. Measurement consisted of three tests. For measurement of weight-bearing: standing with open eyes, standing with closed eyes. Every measurement took 30 seconds and there was a break of 5 seconds between the tests. For the purpose of the study we used measurement assessing standing with open eyes.

Kinesiotherapy

Within spa care the intervention of the ACT took place in the monitored group of patients. The ACT was practised three times per week for at least 20 – 30 minutes every weekday within individual movement therapy. The choice of individual exercises was compiled according to development transitions, according to difficulty of motor patterns, specific diagnosis and individual abilities of each child to carry out a particular motor pattern in high quality. The control group underwent only individual therapy without intervention of the ACT method.

The ACT method exploits isometric contraction of muscle chains in static postural positions (e.g., pressing up on all fours) and this state is called static coactivation, which is further combined with dynamic coactivation (e.g., pressing up from the prone position to the position on all fours) where the trunk is transferred in a stabilisation-locomotor manner through the positions of motor development by pressing up against the acral parts. The result is muscle coactivation in motor patterns and their fixation with daily movement activities [19-23].

Statistical Data Processing

Data gathered during measurement was entered in the database in MS Excel format. Descriptive statistics (i.e., meridian, arithmetic mean, standard deviation) was used for basic description of the cohort. The non-parametric Wilcoxon matched-pairs test was used for testing difference between input and output values. Statistical tests were evaluated with a confidence level of 5%. Stata programme, version 1.3., was used for data processing. Next, the difference was evaluated by means of Cohen's standard deviation ($d < 0.5$ small difference, 0.79 medium difference, 0.8 and more big difference).

RESULTS

The values of the measurement of the monitored group A in the parameter of average load in anterio-posterior direction were between 0.3 and 3.7; output values had lower variability between 0.0 and 3.4; medium value of difference was 0.6. Statistical significance of this parameter was not identified ($p = 0.289$). Input values of the control group in this parameter were between 0.1 and 2.3; output values ranged from 0.2 to 17.8; medium value of the difference was 0.1. Statistical significance was not identified ($p = 0.530$). Cohen's d = 0.8 showed big difference between the groups, i.e., big difference in average output values of the monitored and the control group.

The values of the measurement of the monitored group A in the parameter of average load in medio-lateral direction were between 0.3 and 9.0; output values had lower variability between 0.2 and 5.9; medium value of difference was 0.1. The values were not statistically significant (p = 0.239). Input values of the control group B in this parameter ranged between 0.1 and 6.3; output values were between 0.1 and 4.2. Variability of the output values of the control group was 0.5. The values were not statistically significant (p = 0.326). Cohen's d = 0.5 showed moderate difference between output values of individual groups.

DISCUSSION

The goal of the study was to assess and to compare postural control in various forms of CP by means of Alfa stabilometric platform. The Hypothesis 1 compares output values of the monitored group A and the control group B in the parameters of load distribution in anterio-posterior direction (average deviation on x axis). The Hypothesis 2 compares output values of the monitored group and the control group in medio-lateral direction (average deviation on y axis). The study assesses also the impact of the ACT method on postural stability in the monitored group A where intervention of the method took place for the period of three weeks. The goal of the pilot study was to assess the impact of the neuromuscular ACT method on postural stability in children with cerebral palsy and to compare postural stability in various forms of this neurodevelopmental disorder.

There is no study dealing with this issue in the available literature. We noticed measurement of postural stability on stabilometric platform in children with cerebral palsy in several previous studies [3-4, 13, 16, 20, 24-34].

Within the Hypothesis 1 we observed whether change in output values in parameters of average deviation on y axis (in the AP plane) between the monitored group A with the ACT intervention and the control group B occurs.

The given hypothesis is presupposed on the basis of the research results of these authors: [6, 16, 20, 27, 31, 34]. They observed the impact of balance training on muscle activity in children with CP, the effect of using vibrations within the therapy, the effect of performing a cognitive task while standing, and next they compared postural stability in children with CP and healthy children. In their studies they used stabilometric platform for diagnostics and they measured particularly COP and change in COP oscillation in the AP and the ML plane.

The analysis of COP shift is applied during evaluation of oscillation while maintaining posture. COP depends on COM position. COM is an important factor acting during body oscillation [6]. The CNS chooses the best postural strategy based on sensory information to perform a particular task. These strategies, structured in joint movements, present shift in the AP plane (i.e., ankle, pelvis, trunk and step strategy) and in the ML plane (transfer of weight), as [6] claimed.

Woollacott [34] claimed that children with CP showed better handling skills if they had good postural stability while sitting or standing. Postural stability is good in the sitting position even though children usually sit with trunks flexed. The flexed trunk contributes to abnormal balance and gait while standing or walking [34]. Corrêa [6] compared healthy children and children with CP. Higher amplitudes in the AP and ML plane in children with CP compared to healthy children were recorded in this study. He claimed that sensory deficit may have played a part in higher amplitude and the speed of COP shift. Sensory deficit in children with CP is an important factor for amplitude and COP shift speed increase.

In his study Grecco [16] found out only statistically significant difference in the AP direction between testing with open and closed eyes in both groups. No statistically significant difference in this parameter was identified between both groups. Ju [20] revealed significant difference in both directions of the AP and the ML plane. However, Ju [20] compared a group of children with CP and a control group consisting of children with regular motor development. Reilly [31] claims that postural control in healthy children develops around 7 to 10 years of age. When younger children perform this task while maintaining postural stability, BOS widens, i.e., a wide stance occurs.

The diagnosis of spastic quadriplegia may have influenced the results of the monitored and the control group of children. As Reilly [31] claimed spastic form of CP in children was caused by periventricular leukomalacia producing lesion in the area where prefrontal cortex and other parts of the brain join. That is why children with CP have lower ability to inhibit unintended movements when performing a particular task [31]. Corrêa [6] claimed that muscle imbalance caused by spastic and motor incoordination or shortened and weakened muscles would probably result in temporary muscle contraction and subsequently in spatially inadequate wider and faster oscillation.

Output values in the monitored group A improved in 8 patients. The same happened in the control group B in this parameter. However, no statistically significant value was identified between the groups ($p = 0.3548$).

Next, on the basis of Cohen's d we calculated the output values of the control group B exceeding the average value of the monitored group, i.e., 2.4 cm. The values of 3 patients from the group B were higher than the above mentioned average figure, while they were lower (i.e., 75%) in 9 patients. Cohen's d was $d = 0.5$, i.e., a moderate result between the groups. Small difference between the groups might have been caused by variability of CP diagnosis. Woollacott [4] claims that variability in children with the same diagnosis stresses the significance of individual analysis when assessing the effect of neuromuscular mechanism of training referring to postural management.

Even though the difference in resulting values between the groups was not statistically significant, there was improvement in resulting values in 8 children from both groups. On the basis of arithmetic mean of input and output values there was improvement of 25% in the monitored group A and 21% in the control group B. Improvement in resulting values of average deviation on *y* axis in the AP plane is identical with the studies of Woollacott [4] and Ruck [35]. They recorded decrease in oscillation in the

AP direction, which results in improvement of balance [4]. Ruck [35], who researched the effect of vibrations on children with CP, claimed too that there was reduction in rocking body forward and backward in comparison with the control group. In his study Corrêa [6]also took notice of difference in resulting values in the AP and ML planes, however, there was no statistical significance. Children with CP in comparison with healthy children show ankle strategy less, while hip strategy and rotation for postural control when standing more [13].

We submitted the Hypothesis 2 on the basis of research of autors [8, 13, 24, 28, 31]. These authors observed postural stability in children with CP and children with regular motor development, next they researched the possibility to influence postural stability in children with CP by means of visual feedback and the AFOs effect in the group of children with CP and children with regular motor development. They assessed parameters of length of COP trajectory, deflection in the ML and AP planes.

Burtner [24] claimed that more direction changes in the ML plane were recorded compared with children with regular motor development. He noticed increased deflection also in children with regular motor development who were younger than other children in the group. So, it is possible that ML instability can be caused by a lack of postural experience or maturity in both children with regular motor development, as well as children with CP [24].

Victorio [33] claims that postural strategy is optimized and formed. During infancy (i.e., between 6-10 months) also visual control is important for optimum visual stability. At the age of 5-6 years postural stability is in better condition than at the age of 3 years. However, if we had a child of 5-6 years of age and if we tested postural stability with closed eyes, the results would be similar to a three-year-old child tested with open eyes. At the age of 7-12 years postural stability is almost at the level of an adult. Nevertheless, visual control is still needed. Better integration of postural system is evident in girls at this age.

In his further study Grecco [8] compares the effects of a conveyor belt on static and functional balance in children with CP compared to ground practice of walking. The monitored group showed smaller oscillation in the ML plane with closed eyes compared to the control group.

Rha [13] finally found out that children with CP in all values of the length of route of COP, ML and AP deflections showed higher values in comparison with the group of healthy children and these values were statistically significant too.

In our study when comparing resulting values on *x* axis in the medio-lateral plane it became apparent that there was improvement in output values in 8 patients of the monitored group A with the ACT intervention, while only 6 patients improved in the control group B. However, these results were not statistically significant ($p = 0.193$), which is identical with the studies of Grecco [8] and Rha [13] – their resulting difference between the values was not statistically significant.

If we take into consideration substantive significance, we will count how many patients of the control group B exceed the average output value of the monitored group A with the ACT intervention. Only two patients exceed this average value of 1.4 cm. According to Cohen's $d = 0.8$ there is big difference between output values of the group A with the ACT intervention and the control group B.

Muscle imbalance caused by spasticity, motor incoordination and shortened and weakened muscles lead to temporary muscle contraction and spatially inadequate, thus subsequently wider and quicker oscillation. In an effort to maintain the COM in BOS stability of children with CP can get worse [14].

Grecco [8] claimed that smaller oscillation in the ML direction occurred in 6 children in the monitored group, while only in 3 children in the control group. No statistically significant difference between testing with open eyes and closed eyes in the ML plane was identified. Smaller oscillation in the ML direction with closed eyes can stem from bigger activation of pelvic girdle muscles, which results in bigger stability of pelvis.

Rha [13] did not identify statistically significant difference in resulting values in the ML plane between the monitored and the control group. In output values of healthy children and children with CP Reilly [31] found out that the biggest difference was in ML deviation and in the speed of AP shift. Ju [20] found out a significant difference in the ML plane. In his study, where he compared postural stability in children with CP and healthy children, Majewske [36] arrived at similar results.

Grecco [8] claims that postural management depends on integration of vision, vestibular and proprioceptive perception, orders from the central nervous system and neuromuscular reactions. The diagnosis of ataxia might have increased values in the patient A12 from the monitored group. Reilly [31], who compared postural stability in children with CP and healthy children, claimed that when comparing results in children with CP there was difference between the groups with the spastic and atactic form. A significant decrease in management of the speed of ML shifts was identified in children with the atactic form.

In his study Victorio [33] claims that during development children must discover new strategies and ways of managing the centre of body gravity in both reactive and predictive moments. Age mostly impacts shifts in the ML plane in the centre of gravity, since they require advanced strategies. This fact impacts also the results of our study where the average age of the monitored group was 10.25 +- 4.6 and 8.17+- 3.9 in the control group.

The average age of children from the monitored group in the study of De Araúja [37] was between 7 and 12 years. Araújo [37] claims that postural stability at this age equals postural stability in adults. However, Victorio [33] claims that visual control is necessary. In our study we also noticed defects of vision that might have impacted results of measurement and that might have caused increased values in the ML plane in children in both groups. In his study Araújo [37] noticed the biggest change directly in the ML plane. He attributes these changes to the fact that children with visual impairment exploit more pelvis strategy when they lose balance compared to children without visual impairment.

The ACT method is mainly practised in closed chains in the positions of motor development and its variants, the result of which is spine straightening. Spine straightening occurs on the basis of pressing up against the acral parts of extremities. The ACT method can influence trunk stability and at the same time muscle activity of lower and upper extremities [23]. Exteroceptive facilitation and inhibition for tone balance of antagonistic muscle chains is performed in the ACT [19]. Muscle tone is the basis of motor function and it deals of permanent and light contraction of skeletal muscles [38]. The results of another study [39] support the theory of motor learning and they describe correlation between repetition of activities, improvement of motor functions and subsequently stimulation of motor plasticity. The ACT exploits motor learning. Another study dealing with children with cerebral palsy [40] claims that higher brain centres are often damaged in children with CP. For stimulation of locomotor centres in the spinal cord an optimum amount of afferent excitation is essential. Patient's motivation also plays an important part in results of therapeutic effort. The strongest sensory stimulus for the CNS is activity in isometric contraction. This type of muscle activity is the most natural in ensuring motor function in the regular environment of gravitational field [41]. The ACT method exploits isometric contraction of muscle chains in static positions and this state is called static coactivation, which is further combined with dynamic coactivation, where the trunk is transferred through the positions of motor development and pressing up against the acral parts in a stabilisation-locomotive manner. The result is activation of motor patterns through pressing up against the acral parts and their fixation within daily life movement activities [19].

Dewar [25] describes the impact of possible movement intervention on postural stability in children with cerebral palsy. The study's conclusion claims that it is very important to focus on functional goals when proposing rehabilitation plans. The advantage of the ACT consists in the possibility to train oneself and to practise in home environment where younger children can work out with their parents. Older children can work out independently on the basis of precise instructions in the book and on video.

The therapy of older children with cerebral palsy should be more targeted. It should not include only stretching and body building exercises but also exercise focused on practical use in normal life [42]. Ruck [35] claims that children with CP have obvious poor activity of abdominal muscles, muscle activity in pelvis is not in optimum tension, musculus illiopsas is shortened and trunk extensors are weakened. When flexing femur and at propulsion the trunk is the first to be activated. The results of available foreign studies [13, 16, 24, 28, 31] show that children with cerebral palsy have problems with pelvis stabilisation and weakened and shortened pelvic girdle muscles. However, movement treatment of CP more and more concentrates on extremities than on trunk stability. The ACT method exploits position of motor development and static or dynamic motor coactivation. We chose the following motor patterns within the ACT training of the monitored group: pressing up on all fours and its variants, pressing up to the position of kneeling, pressing up from the position of one foot forward to the standing position, pressing up in the standing position. Pelvis is maintained in postural stabilisation in these pressing up positions.

CONCLUSION

The results of our study showed improvement in resulting values of load distribution in anterio-posterior and medio-lateral direction in the monitored group A, however, they were not statistically significant. The difference between the groups was assessed also by means of substantive significance (Cohen's d). On the basis of the study's results we can state that the Acral Coactivation Therapy influences postural stability in children with CP.

The results show improvement of postural stability, which led to better coping with tasks in common daily activities, improvement in defensive reactions thanks to which children react better to loss of balance and increased awareness of own body scheme. With respect to these facts the ACT method has a positive effect on children with cerebral palsy. Another benefit of the ACT method in the therapy for children with CP is working out in the positions of motor development through pressing up against the acral parts. Motor programmes, or motor patterns, are individually fixed in children with CP, they have a wide variability according to the damage of the CNS, and they are not present in severe forms of CP at all.

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Chapter 4

PROMOTING AMBULATION BASIC RESPONSES IN A CHILD WITH CEREBRAL PALSY AND INTELLECTUAL DISABILITIES THROUGH MICROSWITCHES AND POSITIVE STIMULATION

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ABSTRACT

Background

Children with CP may have balance problems and gait difficulties.

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Objective

This case report illustrates the use of microswitches, walker device, and positive stimulation to promote basic ambulation responses in a child with cerebral palsy and severe to profound intellectual disabilities.

Method

An ABAB reversal design was implemented. During baselines (i.e., A phases) the technology was available but inactive. During interventions (i.e., B phases) a 3 sec positive stimulation was automatically delivered by the system contingently to a step response.

Results

An increased performance was evidenced during the intervention phases. Indices of happiness recorded as an outcome measure of the participant's quality of life were improved.

Conclusion

The rehabilitative program was useful to promote self-determination and independence of the participant while dealing with ambulation responses.

Keywords: cerebral palsy, intellectual disabilities, gait, microswitches, quality of life

INTRODUCTION

Children with cerebral palsy (CP) and severe to profound developmental and intellectual disabilities (DD and ID, respectively) may experience balance difficulties and gait abnormalities combined to locomotion delays and spend a lot of time sitting and/or lying, with negative outcomes on their quality of life. Thus, their clinical conditions may be seriously deleterious for their social image, status, and desirability [1-3]. One way to support their ambulation performance is the use of walker devices combined to microswitches and positive stimulation [4-6]. Thus, by using that equipment the management of standing position and locomotion process might be fostered [7-8]. In fact, postural control and partial weight lifting can be ensured and highly rewarded and positive motivation be provided [9-10]. Specifically, the use of the walker devices alone constitutes a basic feature for a rehabilitative intervention. However, it may be insufficient whenever implemented alone [11]. Because children with CP and significant DD and ID may be relevantly impaired, a valuable modification in their behavioral repertoire may not be evidenced [12]. As a suitable way to deal with this condition and enhance their motivation for ambulation, microswitches and contingent positive stimulation have been adopted [13-15]. That is, microswitches are electronic sensors capable of monitoring step responses and delivering brief periods of motivating and preferred stimuli simultaneously through a technological system [16]. A child with CP and severe to profound DD was exposed to such program accordingly. The objectives of the current case report were (a) assess and extend the use of microswitches and positive stimulation to support the participant' s ambulation basic process, and (b) evaluate its effects on the participant's indices of happiness as an outcome measure of their quality of life.

METHOD

Participant

Charlene (i.e., pseudonymous) was a girl aged of 8.5 years at the beginning of the study. She was diagnosed with spastic CP and estimated as borderline between the severe and profound range of intellectual disabilities, although no IQ score was available because no specific test was feasible due to her clinical conditions. She had neither speech nor self-skills and exhibited quadriplegia. Charlene was capable of few single step responses while equipped with her walker device and extensively helped from a caregiver. She received physiotherapy and speech sessions twice a week. The family favorably appreciated the opportunity presented for Charlene to be involved within such rehabilitative program and signed a formal consent for her participation. The intervention was additionally approved by a scientific and ethic committee.

Reponses and Technology

The adaptive responses consisted of a single forward step response performed by Charlene while equipped with her walker device. Her daily life used device was a four-wheels walker with a frame passing around the chest and under the arms added to a harness securing her posture and lifting a wide part of the body weight. Microswitches adopted to record Charlene's responses were two optic sensors (i.e., circular photocells with1.5 cm of diameter). Both sensors were fixed on forward lateral sides of the walker. They were situated in front one to each other. The microswitches were connected to an electronic control unit which was attached to the walker. The control system unit monitored and counted the forward step responses completed by Charlene. Additionally, during intervention phases it ensured the participant with 3 sec of positive stimulation contingently to each performed forward step. A second forward step performed within 3 sec was ignored by the system because a stimulation was provided [17]. The preferred stimuli to be used as contingent reinforcements during the intervention phases were selected through a formal screening of preference according to Crawford and Schuster [18].

Sessions and Data Collection

Sessions lasted five minutes and were video-recorded. The study lasted two months. Ninety sessions were carried out. Ten sessions for both baselines and eighty sessions for both intervention phases were collected. Overall, Collected data included (a) forward steps performed, and (b) indices of happiness (i.e., laughing, smiling, excited body movements with or without vocalizations) recorded according to a partial interval coding system, with 15 s intervals divided between 10 s of observation and 5 s of recording dichotomously the absence or the presence of the indices of happiness in the previously observed interval [19].

Experimental Conditions

An ABAB reversal design was adopted [19]. A represented baselines, and B the intervention phases. During A phases the technology was available but inactive. An adaptive responding did not produce any environmental consequence. During B phases the technology was available and active. An adaptive responding was followed by a 3 s period of positive stimulation contingently and automatically delivered by the system.

RESULTS

Charlene performed a mean of 4 forward steps (range 1-6) during the first baseline. Her performance significantly improved during the first intervention phase with a mean of 72 forward steps (range 64-96). She reduced her trend during the second baseline with a reduction to 10 forward steps completed (range 4-12). Charlene relevantly enhanced her performance during the second intervention phase up to a mean of 85 forward steps (range 74-100). Similarly, her indices of happiness demonstrated a mean of 4 intervals (range 2-5) during the first baseline. Her positive mood improved up to a mean of 16 intervals (range 12-18) during the first intervention phase. The girl reduced her positive mood to 8 intervals (range 6-9) during the second baseline and increased her performance up to 17 intervals with indices of happiness (range 16-20) during the second intervention phase. Differences between the first baseline and the first intervention and between the second baseline and the second intervention were statistically significant ($p < .001$) to the Kolmogorov-Smirnov test [20]. Two independent raters who watched and coded simultaneously the sessions revealed a mean score of reliability of 98% (range 95-100).

DISCUSSION

Data extended previous findings and supported the suitability and effectiveness of a microswitch-based program and positive stimulation to enhance ambulation performance of a child with CP and severe to profound DD and ID. The AT-based intervention additionally evidenced beneficial outcome on the participant's happiness with positive consequences on their quality of life [21-22]. The results were confirmed within a solid reversal design in which the alternating experimental sequence demonstrated at least a partial awareness acquisition of the microswitch responding. However data should be interpreted with caution because the program was implemented on a single participant and need to be confirmed by further extensions. Nevertheless, two considerations may be putted forward.

First, microswitch-based interventions combined with walker devices and positive stimulation may be helpful to promote highly rewarding motivation of a child with CP and ID added to DD. Such rehabilitative program may be viewed as respectful of the child's dignity and useful to improve her positive mood [23]. Second, new extensions are mandatory to favorably corroborate the validity of such program and eventually combine it with traditional physiotherapy and/or treadmills. Furthermore, non-contingent control phases were recommended to support the awareness of microswitch responding by the participant. Finally, social validation procedures including external raters were suggested to validate both clinical and social resources of the proposed program [24].

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Chapter 5

IMPROVING LOCOMOTION FLUENCY OF A CHILD WITH CEREBRAL PALSY AND INTELLECTUAL DISABILITIES THROUGH A MICROSWITCH-BASED PROGRAM: CONTINGENCY AWARENESS AND SOCIAL VALIDATION

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ABSTRACT

Background

A further extension of the use of microswitch-based programs to improve locomotion fluency of a child with cerebral palsy and mild to moderate intellectual disabilities was assessed. Additionally, an

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evaluation of the awareness of microswitch responding was considered. Finally, a social validation procedure was conducted with 40 psychologists as external raters.

Method

An ABABACACAB experimental sequence was implemented. A indicated baselines. B indicated contingent intervention phases. C indicated non-contingent control phases.

Results

The participants improved their performance during the contingent intervention phases and acquired the awareness of microswitch responding. Social raters positively scored the use of such technology.

Conclusion

The technology was effective and suitable to promote locomotion fluency.

Keywords: cerebral palsy, intellectual disabilities, contingency, quality of life, social validation

INTRODUCTION

Children with cerebral palsy (CP) and intellectual disabilities (ID) may present locomotion problems and gait difficulties due to their clinical conditions, which may seriously hamper their daily quality of life [1]. In fact, they may be quite passive and isolated with negative outcomes on their social image, desirability, and status [2]. To overcome this issue and promote independent responding, one may envisage assistive technology-based programs (AT). A basic form of AT is represented by microswitches, which constitute electronic tools enabling persons with severe to profound and multiple disabilities to profitably cope with their environment [3]. Within this framework, microswitches combined with walker devices and positive stimulation may be considered a great educational and rehabilitative resource aimed at increasing rewarding motivation and enhancing forward steps performance [4].

Furthermore, such interventions may be useful to support locomotion fluency (i.e., multiple forward steps within a range time interval). That goal may be relevant for those individuals who are initially capable of some forward steps but do not have a continuity in their gait [5]. Moreover, one may consider the awareness of microswitch responding. Thus, it may be argued that an increased performance during contingent intervention phases is not due to the acquired awareness of the contingency between the behavioral adaptive response (i.e., forward ambulation steps) and positive stimulation. Rather, it may be associated with the mere presence of the positive stimulation. To assess this issue, one may envisage non-contingent control phases. During such phases positive stimulation will be available throughout the session (i.e., continuously), irrespective of the adaptive responding. Whenever the participant acquired the awareness of the contingency, the adaptive responding along the control sessions should decrease [6].

A further goal within such rehabilitative strategy may be the confirmation of both clinical and social validity by external raters. For that purpose, one may include social validation procedures [7]. During a social validation assessment, external raters who have a professional or a personal background with developmental disabilities and rehabilitative interventions evaluate the participants within standard experimental conditions (e.g., baseline, contingent intervention phase, and non-contingent control phase) and fill a questionnaire on 5-points Likert-like scale, considering (a) comfort, (b) self-determination, (c) rehabilitative value, (d) suitability for daily use, and (e) personal involvements as dimensions [8].

Accordingly with the above, the rehabilitative objectives of the current case report were (a) further extension of microswitch-based programs (MBP) to enhance locomotion fluency in a boy with CP and mild to moderate intellectual disabilities, (b) evaluate the awareness of microswitch responding, and (c) carry out a social validation procedure involving 40 psychologists with a 10-years professional experience as external raters.

METHOD

Participant

Danny was a 9-years old boy diagnosed with CP and spastic tetraplegia. Although no formal IQ was available because no specific tests were feasible, he was estimated as borderline between the mild and moderate range of intellectual disabilities based on clinical observations. He presented lack of speech and was unable of sphincter control. He attended regular classes with a special education program and a support teacher 24 h per week. He followed sensorial stimulation sessions 3 days per week. He was reported as quite passive and isolated by his family members. He was capable of few forward step responses once equipped with his walker device. His parents were enthusiastic of the opportunity to be included in a MBP and signed a formal consent for the participation of Danny within the rehabilitative intervention, which was approved by a local scientific and ethic committee. The program was carried out according to Helsinki Declaration and its later amendments.

Response and Technology

The adaptive response consisted of 4 forward steps to be performed within a 3 s of interval time (i.e., outcome measure of locomotion fluency). Danny was equipped with his walker device during the sessions. The microswitch consisted of a circular photocell (i.e., 1.5 cm of diameter), which was fixed on the left forward side of the walker device. In front of it, on the right forward side a squared 40 x 40 cm reflector panel was adjusted. A control system unit ensuring (a) the counting of microswitch activations, (b) adaptive responses recording, and (c) the automatic delivery of brief periods of positive stimulation during the contingent intervention phases (i.e., uniquely referring to the latter point) was additionally available on the walker device. By performing a forward step Danny interrupted the light beam between the optic sensor (i.e., the photocell) and reflector panel. A microswitch activation was automatically recorded. Whenever 4 microswitch activations were included within 3 s an adaptive response was counted. A further adaptive response performed by Danny within 3 s was ignored by the system [9]. The positive stimulation to be used during intervention phases (i.e., both contingent and non-contingent) was selected according to a screening preference procedure completed according to Crawford and Schuster [10].

Sessions and Data Collection

Sessions lasted 5 minutes and were video-recorded. The study lasted approximately three months. Four sessions, five days per week were collected. Overall, one-hundred and fifty-five sessions were carried out. Specifically, five sessions were included in each baseline. Thirty sessions were included in each contingent intervention phase. Twenty sessions were included in each non-contingent control phase (see below, experimental conditions). Data collection concerned (a) the adaptive responding (i.e., 4 forward steps performed within 3 s interval), and (b) social validation scores.

Experimental Conditions

The study was conducted according to an ABABACACAB experimental sequence [11]. A represented baselines. The technology was available but inactive. No environmental consequences were delivered even if an adaptive responding was performed. Five sessions were collected for each phase completed within two days. B represented contingent intervention phases. The technology was available and active. A 3 s period of positive stimulation was automatically delivered by the system contingently to an adaptive responding. Thirty sessions were collected for each phase completed along two weeks. C represented non-contingent control phases. The positive stimulation was available and automatically delivered by the system throughout the sessions irrespective of the participant's adaptive responding. Twenty sessions were collected along a week for each phase.

Social Validation

Forty psychologists (16 men and 24 women) with a minimum professional experience in the field of developmental disabilities and cognitive-behavioral rehabilitative strategies of 10 years were involved as external raters in a social validation procedure. Their mean age was 44.5 (range 38-58), and the standard deviation was 7.24. They were exposed to a 6 min video which included 2 min standard session of baseline, 2 min standard session of contingent intervention phase, and 2 min standard session of non-contingent control phase. They were told that were requested to watch the video of a child with CP and ID in three different experimental conditions, namely (a) baseline with the technology available but inactive, (b) contingent intervention phase with an automatic stimulation provided by the system contingently to an adaptive responding, and (c) a non-contingent control phase with the positive stimulation automatically available throughout the session irrespective of the participant's adaptive responding. They were equally divided in 8 groups of 5 raters. The presentation sequence of the videos (i.e., ABC, ACB, BAC, BCA, CAB, CBA) was randomly distributed among the groups to minimize sequence effect. The raters were requested to fill a 6 item questionnaire (see Table 1) with a 5 points Likert-like scale in which 1 and 5 indicated the less and the more positive scores respectively.

Table 1. Social validation questionnaire

1. Do you feel the child was comfortable in the condition?
2. Do you the feel the condition promotes child's self-determination?
3. Do you feel the condition has beneficial effects/rehabilitative goals?
4. Do you feel the condition is suitable for home settings?
5. Do you feel the condition is suitable for medical/rehabilitative settings?
6. Do you agree (i.e., would like to be involved) with the condition?

RESULTS

Collected data were summarized in Tables 2 and 3. Table 2 included Danny's performance along the experimental phases. As data evidenced, his performance was very low during baselines. The performance significantly increased during contingent intervention phases and decreased along non-contingent control phases with scores higher than in baselines and lower if compared to the contingent intervention phases, suggesting that Danny acquired the awareness of microswitch responding. Differences between the experimental phases were statistically significant ($p<.01$) to the Kolmogorov - Smirnov test [12].

Table 2. Mean scores and ranges of Danny performance

A	**B**	**A**	**B**	**A**	**C**	**A**	**C**	**A**	**B**
9	40	12	45	8	18	6	16	9	49
(6-11)	(35-44)	(9-13)	(42-49)	(7-9)	(15-20)	(5-8)	(14-18)	(6-12)	(43-50)

An ANOVA (i.e., one way) model was performed to evaluate the social validation scores. Data showed that $F(2, 37) = 16.38$ ($p<.001$) differences were statistically significant among conditions. Post-hoc comparisons revealed that differences emerged among the three experimental conditions ($p<.05$), with higher discrepancies between baselines and contingent intervention phases, although each condition was statistically different from each other.

Table 3. Social validation scores (means and standard deviations)

A	B	C
2.25 (.054)	4.56 (.052)	3.34 (.056)

DISCUSSION

Data of the current investigation revealed the suitability and the effectiveness of a MBP to promote locomotion fluency in a boy with CP and mild to moderate ID. His performance significantly improved during contingent intervention phases if compared to the baselines. Furthermore, the awareness of microswitch responding was empirically demonstrated. Thus, his performance was suggested to be closely linked to the acquisition of the contingency between locomotion and positive stimulation. Social raters favorably scored and formally endorsed the use of such technology for rehabilitative purposes (i.e., data listed on Table 3 referred on all the items). Accordingly, previous studies [13-14] were confirmed and the following considerations were putted forward.

First, a MBP may be effective and suitable to enhance independent locomotion fluency and improve self-determination accordingly. Highly rewarding motivation was provided and the participant acquired the awareness of the contingency between the behavioral responses and environmental consequences rather than increasing his adaptive responding because a positive stimulation was available. The learning process was corroborated because Danny responses systematically varied according to experimental conditions [15-17].

Second, external social raters favorably scored the use of the technology and differentiated their evaluations between conditions. Thus, the scores were higher for the contingent intervention phases and lower along the baselines, with middle scores during non-contingent control phases. The trend indicated that external raters positively appreciated differences between the experimental conditions similarly to Danny's performance. Essentially, both social and clinical validity of the rehabilitative program was empirically corroborated [18-20].

Although the promising and encouraging results, caution was undoubtedly mandatory because this was a single-case report. Further extensions were necessary to (a) demonstrate the efficacy on other dependent variables (e.g., positive mood), and (b) consolidate and generalize the learning process through follow-up, maintenance, and/or generalization phases.

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Chapter 6

ENABLING OBJECT MANIPULATION AND REDUCING HEAD TILTING OF A BOY WITH CEREBRAL PALSY AND SEVERE TO PROFOUND DEVELOPMENTAL DELAYS THROUGH A MICROSWITCH-CLUSTER TECHNOLOGY

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ABSTRACT

Background

Microswitch-cluster technology represents basic assistive tecchnology-based programs aimed at pursuing the simultaneous dual

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goal of promoting an adaptive responding and decreasing a challenging behavior.

Objective

An extension of the technology was adopted to a boy with cerebral palsy and sever to profound developmental delays to enhance object manipulation and reduce head tilting.

Method

An ABB^1AB^1 experimental sequence was implemented in which A indicated baselines, B indicated the contingent intervention irrespective of the challenging behavior, and B^1 indicated the cluster (i.e., the adaptive responding was positively reinforced only if it occurred in absence of the challenging behavior).

Results

Showed that the participant significantly increased his adaptive responding and reduced the challenging behavior during cluster phases.

Conclusion

The microswitch-cluster technology was helpful to pursue the dual goal of promoting an adaptive responding and decreasing a challenging behavior.

Keywords: cerebral palsy, challenging behavior, assistive technology, quality of life

INTRODUCTION

A basic objective of a microswitch-based program (MBP) for a child with CP and multiple disabilities is to help the child to acquire an adaptive responding which may be useful to independently access to favorite stimuli. Once the adaptive responding was learned and the child was highly motivated to be active, a new crucial rehabilitative goal may be pursued such as improving response schemes [1]. For instance, one may initially envisage an object manipulation as a way to constructively engage the child in a occupational activity [2]. Once the child consistently improved his performance, one may consider to positively reinforce the adaptive responding without dystonic movements (e.g., head tilting). The dual goal may be reached through a microswitch-cluster technology, namely a rehabilitative intervention designed to pursue both objectives simultaneously [3-4]. A cluster-technology includes two microswitches: (a) a first sensor capable of detecting the adaptive responding, and (b) a second technological device helpful to monitor the challenging behavior [5-6].

According to the aforementioned example, a wobble microswitch which needs to be pulled, pushed, or moved side way to be activated might be useful to control and improve object manipulation. Conversely, a tilt sensor may be adopted to record head tilting [7-8]. The current study investigated the opportunity for a boy with CP and severe to profound developmental disabilities to be exposed to a microswitch-cluster technology aimed at increasing object manipulation and regulating postural control (i.e., head dystonic tilting).

METHOD

Participant

Colin was a boy aged of 10.4 years diagnosed with spastic tetraparesis and CP. He presented dystonic movements, lack of speech and self-help skills. Although no formal IQ was available since no specific test was feasible, he was estimated between the severe and profound range of developmental disabilities. He had normal sensorial skills and lived at home with his parents. He attended regular classes and followed a special educational program focused on occupational and communicative activities helped by a support teacher. His family considered the microswitch-cluster technology highly promising and signed a formal consent for the participation of Colin to the rehabilitative intervention, which was additionally approved by a local ethic and scientific committee.

Technology and Response

The adaptive response was object manipulation. The challenging behavior was constituted by a dystonic forward, backward or lateral head tilting. A wobble microswitch was adopted for detecting the adaptive response. That is, a ball was fixed on the table in front of the participant who was sat in a wheelchair. The wobble to be activated needed to be pulled, pushed, or moved left or right side. A tilt microswitch was adjusted on the hat worn by the participant. Both represented the cluster [9]. A control system unit ensuring the response counting and stimulation delivery (i.e., except for baselines, see below experimental conditions) was additionally available. The favorite stimuli to be used as reinforcements were selected according to the screening preference stimuli by Crawford and Schuster [10].

Sessions and Data Collection

Sessions lasted 10 min and were video-recorded. The study lasted approximately 3 months. Overall, one hundred sessions were collected. Data collection concerned (a) the adaptive responding, and (b) the challenging behavior. Both dependent variables were measured according an event recording system [11].

Experimental Conditions

The study was conducted according to an ABB^1AB^1 experimental sequence [12]. A indicated baselines. The technology was available but inactive. An adaptive responding performed did not produce any environmental consequence even if it occurred in absence of the challenging behavior. Five sessions were collected for each baseline phase. B indicated contingent intervention aimed at increasing the adaptive responding irrespective of the challenging behavior. Thus, contingently to an adaptive responding 10 s of positive stimulation were automatically delivered by the system irrespective of the presence of the challenging behavior, which was monitored. Thirty sessions were collected along two weeks. B^1 indicated the cluster. Positive stimulation was automatically delivered by the system only if it occurred free of the challenging behavior. Thirty sessions were collected for each phase along two weeks.

RESULTS

Data were summarized in Table 1. During the first baseline, Colin had up to 5 adaptive responding contingently to the 100% of the challenging behavior. During the first intervention, the participant increased his adaptive responding up to 50 with a high level of challenging behavior (78%). During the cluster phase the participant further improved his performance up to 55 adaptive response with a lower level of challenging behavior (i.e., up to 22%). During the second baseline, the participant inverted his trend with a maximum of 10 adaptive responses and a higher level of the challenging behavior (i.e., up to 95%). Finally, during the last cluster phase, he significantly learned the use of the technology with a higher level of adaptive responses (i.e., up to 58) and a relevant low level of the challenging behavior (i.e., up to 15%). All differences between the experimental phases were statistically significant ($p < .01$) to the Kolmogorov-Smirnov test [13].

Table 1. Colin performance (within brackets the ranges)

A		B	B¹	A	B¹
Means	3(1-5)	45 (40-50)	50 (48-55)	7 (5-10)	55 (52-58)
Means	100%	72% (70-78)	18 (15-22)	90 (88-95)	12 (10-15)

The first row reported the adaptive responding while the second row indicated the challenging behavior.

DISCUSSION

Data indicated that the use of a microswitch-cluster technology was effective and suitable for promoting object manipulation and decreasing head tilting by a child with CP and severe to profound developmental disabilities. The results were consistent with previous findings [14-16] and emphasized the active role, constructive engagement and positive occupation of the participant, pursuing the intervention dual goal [17-18]. Finally, the findings corroborated the validity of self-directed rehabilitative programs as an integrative support to traditional physiotherapy strategies [19-20]. New research should deal with further extensions aimed at clarify the generality of such results and evaluate modalities to integrate the technologies and procedures within daily settings.

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Chapter 7

TEACHING COMMUNICATION SKILLS THROUGH AN ASSISTIVE TECHNOLOGY-BASED PROGRAM TO A CHILD WITH CEREBRAL PALSY

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ABSTRACT

A child with cerebral palsy and moderate intellectual disabilities was exposed to an assistive technology-based program to enhance academic activities and communication skills. A hierarchical computerized system was implemented. Indices of positive participation were additionally recorded as an outcomes measure of the participant's quality of life. An ABAB reversal design was adopted. Finally, thirty-two support teachers were involved as external raters in a social validation procedure. Results showed that the boy increased his performance and was positively occupied during intervention phases. External raters favorably endorsed

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the use of such program. Clinical, educational, and psychological implications of the findings were critically discussed.

Keywords: cerebral palsy, academic activities, communication skills, request and choice, positive participation, social validation

INTRODUCTION

Beside motor impairments and postural abnormalities combined with gait difficulties, children with CP may have intellectual disorders and communication problems [1]. Such situation may significantly compromise academic participation and social interactions with peers and/or adults (e.g., teachers and school staff) [2]. To overcome this issue, assistive technology-based programs (AT) may be helpful through hierarchical computerized systems [3]. Thus, by selecting a simple behavioral response already available in the person's repertoire and requesting its repetition to request and choice desired items, a child with CP would be capable of selecting a preferred option and getting it through the mediation of a caregiver [4]. The described hierarchical system included a 4-steps response finalized at reducing the participant's unintentional choice [5]. Next to the positive adaptive responding, one may examine positive participation as an outcome measure of constructive engagement and quality of life [6]. Finally, external raters involved in a social validation assessment might corroborate both social and clinical validity [7].

In light of the above, the rehabilitative objectives of the current study were (a) to extend previous findings to a new participant with CP and moderate intellectual disabilities (ID), (b) to evaluate the beneficial effects on positive participation, and (c) to carry out a social validation procedure including 32 support teachers as external raters.

METHOD

Participant

Andy was a 8.5 years old boy with CP and moderate ID. He presented lack of speech and self-help skills. He attended regular classes with a special education program implemented by a support teacher 24 h per week. He followed stimulation sessions during the afternoon 3 days per week.

His parents described Andy as quite passive and disengaged. They considered the opportunity to be involved in AT-based program for teaching communication skills highly desirable and promising. In fact, they signed a formal consent for the participation of Andy to the rehabilitative intervention, which was approved by a local ethical and scientific committee.

Technology and Response

The technology included a laptop equipped with clicker 5 software package (Crick House, Moulton Park, Northampton, UK), a circular pressure microswitch with a 12 cm of diameter, and an interface connecting the microswitch to the laptop. The homepage of the computer screen presented two pictures (i.e., personal needs or academic activities) automatically scanned (each 1.5 sec) through a red coloured encirclement. Once the academic option was selected (i.e., through microswitch activation), three new pictures were available. That is, a little boy who was looking for/listen to a story (Italian literature option), a little boy who was looking for/listen to arithmetic operations (mathematics option), a little boy who was looking for/listen to a landscape (geography option). Selecting the Italian box (i.e., activating the microswitch once the box was encircled) the system allowed the opening of a second page with the four basic literature operations available (i.e., reading, composing, commenting, and grammar). Selecting the grammar box (i.e., once again through microswitch activation contingently to its encirclement) the system allowed the opening of a third page with four opportunities of grammar exercises (i.e., customer tailored, depending on their characteristics/skills, in accordance with the support teachers). For example, selecting the adjectives option, led the system to ask: Do you really want to know what an adjective is? The fourth page was provided with two main boxes: that is "yes" (green coloured) and "no" (red coloured). Responding yes would provide the definition of an adjective with a new box. The final box was combined with preferred stimulation, automatically delivered by the system for 8 sec, in order to serve as a positive (primary) reinforcement. The adaptive response consisted of a right hand pressure on the circular pressure microswitch fixed on the table in front of himself on the right side of the laptop. The activities and the items were selected according to Crawford and Shuster stimulus preference screening [8].

Sessions and Data Collection

Sessions lasted 10 min and were video-recorded. The study lasted approximately 2 months. Overall, 70 sessions were collected. Data recording concerned (a) request and choice of an academic activity or a personal need, (b) indices of positive participation (i.e., alerting, gaze-oriented, laughing, smiling, excited body movements with or without vocalizations, completion of a request and choice hierarchical process), and (c) social validation scores. Indices of positive participation were recorded according to a 15 sec time interval with 10 sec of observation followed by 5 sec of dichotomous coding of absence or presence regarding positive participation in the previous observed interval [9]. Two independent researchers watched simultaneously the sessions and assessed the reliability, which resulted of 95% 8range 92-100) [10].

Experimental Conditions

The study was carried out according to an ABAB reversal design [11]. During the baselines (i.e., A phases) the technology was available and active. Andy was requested to complete the request and choice process through a traditional mouse. Five sessions were collected along two days for each baseline phase. During the intervention (i.e., B phase), the technology was available and active as in baseline. However, Andy could use the microswitch to complete the request and choice process. Thirty sessions were collected for each phase along three weeks.

Social Validation

Table 1. Social Validation Questionnaire

1. Do you feel the participant is comfortable in the condition?
2. Do you feel the condition promotes self-determination?
3. Do you feel the condition has beneficial/rehabilitative outcomes?
4. Do you feel the condition is suitable for daily settings?
5. Do you agree (would like to be involved) with the condition?

Thirty-two support teachers (mean age 39.5 and standard deviation 6.48) were included in a social validation procedure. They were equally and randomly divided in eight groups. Each group was requested to watch a standard 3 min session of the baseline, and a 3 min standard session of the intervention. The sequence of the watched presentations was systematically and randomly varied (i.e., A-B and B-A) to balance experimental conditions. They were told that they could observe a boy with CP and ID in two different conditions. In one condition the participant managed the technology with a traditional mouse and in a second condition he had the opportunity to manage the technology with a pressure microswitch. The support teachers were requested to fill a 5 items questionnaire and evaluate the dimensions on a 5 point Likert-like scale in which 1 and 5 represented the less and the more positive scores respectively (see Table 1) [12].

RESULTS

Data were summarized in Tables 2 and 3. Performances and indices of positive participation systematically varied along the experimental phases demonstrating the acquisition of the learning process. Differences between the first baseline and the first intervention and between the second baseline and the second intervention were statistically significant ($p < .01$) to the Kolmogorov-Smirnov test [13].

Table 2. Andy's performance (mean values and ranges)

	A	B	A	B
Performance	0	64 (62-70)	0	85(82-96)
Participation	0	32 (30-36)	0	(34(32-40)

Support teachers favorably endorsed the technology. Paired *T* Test (31) = was included between 16.65 and 17.54 ($p < .001$).

Table 3. Social validation scores (mean values and standard deviations)

Dimensions	**A**	**B**	***T* Test**	***P***
Comfort	2.23 (.44)	4.22 (.45)	16.96	<.001
Self-determination	2.35 (.42)	4.31 (.47)	16.88	<.001
Rehabilitation	2.44 (.43)	4.56 (.49)	17.54	<.001
Suitability	2.52 (.48)	4.39 (.46)	16.65	<.001
Agree	2.16 (.46)	4.15 (.41)	16.72	<.001

Discussion

Data confirmed previous findings [14-15] and evidenced the suitability and the effectiveness of an AT-based program to promote academic activities and communication opportunities by a child with CP and ID. Andy was capable of communicate his needs profitably during both intervention phases if compared to the baselines. Accordingly, he was positively occupied and constructively engaged. In fact, indices of positive participation improved as well. Support teachers favorably endorsed the use of the technology for communication purposes. The results suggested the following considerations.

First, an AT-based intervention with customer-tailored adapted solutions may be helpful for children with CP and ID who are requested to deal with everyday life environmental requests. The adopted technological options were effective and suitable to promote the independence of Andy and enabled the participants to efficiently cope with his environment and communicate with others [16-17].

Second, his positive participation as a sign of constructive engagement improved as well. Thus, Andy was constructively engaged and assumed an active role through the use of the technology. One may argue that his quality of life was enhanced with positive outcome on both family and caregivers. Additionally, he seemed to enjoy the sessions with beneficial effects on his social image, status and desirability [18].

Third, external support teachers favorably endorsed the use of the technology through a social validation procedure. In fact they positively scored the adoption of such technology on all the investigated dimensions. One may argue that both clinical and social validity were corroborated [19-20].

Caution was surely needed while interpreting the results. It was a single-case report and further extensions were mandatory. Follow-up, generalization, and maintenance phases were recommended. A combination of such options with literacy process and access enabling individuals with CP and extensive motor impairments who are estimated within the normal range of intellectual functioning with further communication skills was suggested. An extended inclusion of new groups of experts in social validation procedures was finally indicated.

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About the Editor

Fabrizio Stasolla, PhD, has a post-doctoral degree. He is an Associate Professor at Giustino Fortunato University of Benevento. His topic concerns the assistive technologies for children with multiple disabilities, developmental disabilities, autism spectrum disorders, ADHD, Rett and down syndromes, cerebral palsy, congenital encephalopathy, fragile X syndrome, post-coma patients who are in a vegetative state either in a minimally conscious state or are emerging/emerged from it. His interest deals with cognitive-behavioral interventions and aided-alternative and augmentative communication strategies for nonverbal individuals, and/or for persons who are estimated within a normal intellectual functioning but who present pervasive motor disabilities. He teaches developmental psychology to educational sciences and psychology students. Furthermore, he works on technological supports, PECS, VOCA, SGD, literacy process, ambulation responses, self-monitoring and self-management of instruction cues to promote on-task behavior of students with learning disabilities. Finally, his framework is focused on behavioral strategies and technological aids for pursuing the dual goal of enhancing adaptive responses and reducing challenging behaviors by children with severe to profound developmental disabilities. From 2013 up to present, he is ad-hoc reviewer for 25 peer-reviewed journals, he serves on the editorial board of

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