Analysis of muscle activation in children and adolescents with severe cerebral palsy

Análise da ativação muscular em crianças e adolescentes com paralisia cerebral grave

Franciele Zardo *
Tatiane Paludo
Brenda Tubelo Pereira de Mattos
Bruna Frata
Chen Chai Ling
Fernanda Cechetti

Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA), Porto Alegre, RS, Brazil

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*** Correspondence:** francielez@ufcspa.edu.br

Abstract

Introduction: Children and adolescents with spastic quadriparesis have a worse selective motor control, and studies with this population are still very scarce. The same is true with scientific evidence of one of the methods most used as a physiotherapeutic treatment in this population, the Bobath Concept. **Objective:** To evaluate spine erector muscles activation, gluteus medius and gluteus maximus, through the handling of the Bobath Concept and the sustained kneeling posture in subjects with a diagnosis of severe cerebral palsy; and to compare muscle activation with a reference group, in order to increase the reliability of this study. **Methods:** A cross-sectional study was carried out with 38 children and adolescents with cerebral palsy, classified by GMFCS at levels IV and V, and 20 healthy participants, aged between 3 and 18 years. They were submitted to the handling of the Bobath Concept and to the sustained kneeling posture, with muscle activation obtained by electromyography. **Results:** We observed significant muscle activation during handling in side-sitting, with weight transfer and without the help of another therapist, and in the sustained kneeling posture, for the erector of the spine and gluteus medius. **Conclusion:** The evidence from this study suggests that both the handling in side-sitting and the sustained kneeling posture cause significant muscle activation in the erector of the spine and gluteus medius for severe quadriparesis subjects, GMFCS IV and V, which can contribute to the improvement of postural control and decision-making in physical therapy practice.

Keywords: Cerebral palsy. Electromyography. Muscles. Physical therapy modalities. Quadriparesis.

Resumo

Introdução: *Crianças e adolescentes com quadriparesia espástica apresentam pior controle motor seletivo e estudos com essa população ainda são muito escassos. O mesmo ocorre com as evidências científicas de um dos métodos mais utilizados como tratamento fisioterapêutico nessa população, o Conceito Bobath.* ***Objetivo:*** *Avaliar a ativação dos músculos eretores da coluna, glúteo médio e glúteo máximo por meio do manuseio do Conceito Bobath e da postura ajoelhada sustentada, em indivíduos com diagnóstico de paralisia cerebral grave; e comparar a ativação muscular com um grupo de referência, a fim de aumentar a confiabilidade deste estudo.* ***Métodos:*** *Realizou-se um estudo transversal com 38 crianças e adolescentes com paralisia cerebral, classificados pelo GMFCS nos níveis IV e V, e 20 participantes saudáveis com idade entre 3 e 18 anos. Eles foram submetidos ao manuseio do Conceito Bobath e à postura ajoelhada sustentada, com ativação muscular obtida por eletromiografia.* ***Resultados:*** *Observou-se ativação muscular significativa durante o manuseio na posição sentada de lado, com transferência de peso e sem auxílio de outro terapeuta, e na postura ajoelhada sustentada para o eretor da coluna e glúteo médio.* ***Conclusão****: As evidências deste estudo sugerem que tanto o manuseio na posição sentada de lado quanto a sustentação da postura ajoelhada causam significativa ativação muscular no eretor da coluna e glúteo médio para indivíduos com quadriparesia grave, GMFCS IV e V, o que pode contribuir para a melhora do controle postural e tomada de decisão na prática fisioterapêutica.*

Palavras-chave: *Paralisia cerebral. Eletromiografia. Músculos. Modalidades de fisioterapia. Quadriparesia.*

Introduction

Cerebral palsy (CP) is the most prevalent type of non-progressive physical disability amongst children, resulted from injury in a developing brain. Such disability may vary in terms of timeframe, place, clinical implications and severity of the brain damage.[1,2] Its general prevalence is 2.1 per 1000 live births in developed countries and between 2.0 and 2.8 in developing countries.[3,4]

In order to perform daily activities properly, many children spend the majority of their time sitting. The more severe cases (levels IV and V), classified by the Gross Motor Function Classification System (GMFCS),[5,6]demonstrate a lack of postural adjustment, not being able to sit independently. Factors such as spasticity, muscle weakness, excessive coactivation of agonist/antagonist muscles, decreased muscle coordination, and decreased response variability can contribute to this condition.[7] Therefore, it is possible to presume that children who lack a basic postural component will never learn to sit independently, even with extensive practice,[8] drastically limiting their functional mobility and daily life activities.[9]

In the literature, evidence around physiotherapeutic approach employed in children with spastic quadriparesis CP type is very restricted.[10] The majority of studies focus on children in I, II and III GMFCS levels, since these have a higher capacity in having selective motor control. Given that the focus in services related to secondary disabilities increases over time, more information from therapists would be useful to determine more efficient interventions, especially for children with reduced functional capacity.[11]

The Bobath Concept, also known as neurodevelopmental therapy (NDT), is placed among the most commonly used approaches for motor intervention in CP[12-14] and is a strategy that aims to improve gross motor function and postural control, facilitating muscle activity through key control points assisted by the therapist.[15] The NDT emphasizes individualized therapeutic handling based on movement analysis, and therapeutic handling aims to enable participation in meaningful activities.[16] The Bobath Concept is inclusive and used with individuals of any age who have suffered damage to their central nervous system, regardless of the degree of severity. It is a facilitation via handling to enable the individual to have an experience of movement that is not passive, but one that they cannot yet do alone.[17]

Clinical research that assesses muscular activation after the Bobath Concept handling facilitations in children and adolescents more severely affected,[18] and that quantifies the effects that such therapy model may offer to this select public are still scarce.[18-21] Using electromyography (EMG) may be of great value in the neurorehabilitation field.[22]

Therefore, the aim of this cross-sectional study was to verify the activation of the erector muscles of the spine, gluteus medius and gluteus maximus through the handling of the Bobath Concept and the kneeling posture in children and adolescents with diagnosis of severe CP, as well to provide data for therapists to be used during the sessions. The Bobath Concept was chosen due to its popularity among therapists, although it lacks scientific proof. The sustained kneeling posture, in addition to being able to be used as a transition during handling due to its use in physical therapy practice, was chosen because of its popularity among therapists in the area. The hypothesis of this study was that the handling and postures to which participants with CP would be submitted differ in relation to muscle activation.

Methods

A cross-sectional study was carried out after approval by the Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA) Ethics and Research Committee (2.464.114). The STROBE checklist was strictly followed for scientific writing.

Participants

Two groups of children and adolescents participated in this study, being a sample for convenience: one composed of 38 individuals diagnosed with CP (GMFCS IV and V), and the other composed of 20 healthy individuals. A state work was conducted between August 2019 and March 2020 in rehabilitation centers in Rio Grande do Sul, Brazil. The data collections were conducted in a single moment, always by the same therapists, and participants were assessed through the following instruments: initial assessment form, Gross Motor Function Classification System (GMFCS), and Modified Ashworth Scale (MAS). The assessment form was developed by the researchers themselves, where the patient's identification data and relevant research information were recorded, such as clinical diagnosis, recent botulinum toxin application and surgeries. The GMFCS is a tool that classifies children with CP's functional abilities in five levels, considering that higher levels indicate higher severity.[23] MAS is a classification method for spasticity, ranging between 0 and 4, being 0 no tonus increase and 4 the affected parts presenting flexing or extension rigidity.[24]

Participants were required to attend to the following inclusion criteria: CP diagnosis and topographic distribution of tonus alteration in spastic quadriparesis;[25,26] age between 3 and 18 years; to be classified between IV and V GMFCS levels.[5] Exclusion criteria were: to have applied botulinum toxin 6 months prior to the intervention, and to present physical abnormalities, genetic or severe syndromes. Written consent was obtained from the responsible institutional coordinators, parents and responsible party for the children ahead of the start of this study.

Protocols of intervention

For clinical research, participants were positioned on the floor, on a mat. This handling was chosen for being widely used in clinical practice. The key control points were used based on the Bobath Concept, with the aim of facilitating weight transfer and muscle activation. The protocol for intervention was:

1 - Side-sitting with trunk rotation and without weight transfer (Figure 1A). Side-sitting with trunk rotation and weight transfer in upper limbs in a wedge (Figure 1B), being the key point in the hip and elbow. Side-sitting with trunk rotation and weight transfers in upper limbs in the wedge, with the help of another therapist (Figure 1C), being the key point in hip and bilateral fist.

2 - On the prone position rolling to lateral decubitus (Figures 1D, 1E), being the key point in bilateral knee. On the prone position rolling to lateral decubitus, with the help of another therapist, being the key point the knee and bilateral elbow (Figure 1F).

3 -Sustained kneeling posture with rolling support, with a key point in bilateral hip (Figure 1G).

The chosen handlings, such as side-sitting and rolling and the kneeling posture, reflect simple activities that can be performed in the daily life of this more severe population. There is still no comparison in the literature of effectiveness between one or two therapists during therapies. In order to increase the reliability of this study, a group of healthy children were included as muscle activation equivalence data.

The assessment was undertaken by three trained researchers, one being responsible for the collection of the EMG signal and the other two for the handling of the subjects. All the individuals were subjected to the same handling standards, always by the same researchers. When collaboration or understanding support was required for any of the subjects, verbal and visual stimulus were used. The acquisition of the EMG signal was undertaken during the resting and handling of the children during 10 seconds. A one-minute rest and change of posture interval was applied in order to return to baseline levels.[18,21,27]

The sequence of handlings was randomized at every three participants, through opaque and sealed envelopes. The randomization was undertaken by an independent researcher who was not involved in the selection process and did not have access to the children's clinical information.

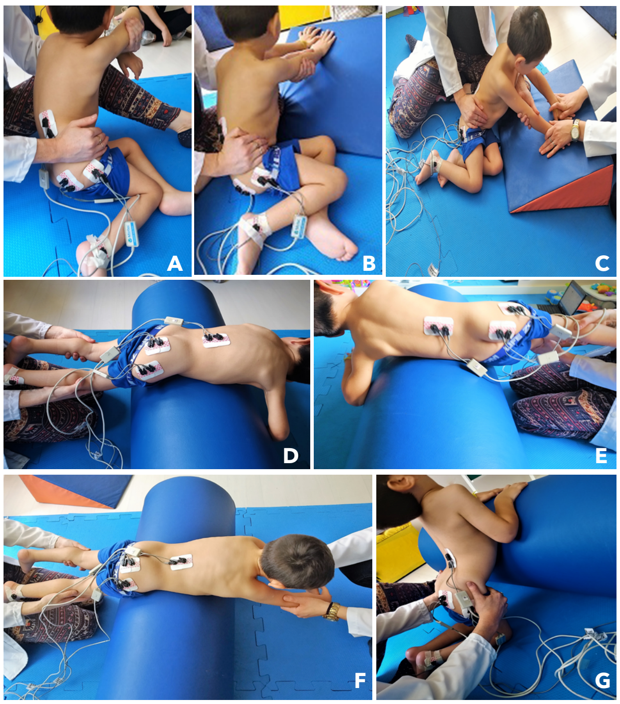

Figure 1 - Handling of Bobath Concept and sustained kneeling posture. **A -** Side-sitting with trunk rotation and without weight transfer. **B -** Side-sitting with trunk rotation and weight transfer in upper limbs in a wedge. Key point: hip and elbow. **C -** Side-sitting with trunk rotation and weight transfer in upper limbs in the wedge, with the help of another therapist. Key point: hip and bilateral fist. **D and E -** On the prone position rolling to lateral decubitus. Key point: bilateral knee. **F -** On the prone position rolling to lateral decubitus, with the help of another therapist. Key point: bilateral knee and elbow. **G -** Sustained kneeling posture. Key point: bilateral hip.

Analysis

Data collection and processing

The EMG signal was collected following the guidelines of the International Society of Electrophysiology and Kinesiology (ISEK) and the SENIAM project (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles). The signal was captured using self-adhesive Ag/AgCl electrodes with a bipolar configuration and diameter 2.2 cm (from the 3M brand). The center-to-center distance between the electrodes was 20 mm, as recommended by SENIAM.[28] To obtain data, the skin impedance was reduced through asepsis and mild abrasion with cotton soaked in 70% alcohol. The electrodes were positioned longitudinally to the muscle fibres,[29,30] on the right side of the body in erector of the spine, gluteus medius and gluteus maximus. The choice of one side of the body followed previous studies[18,20] and the fact that the handling is performed for the same side of muscle activation.[22] The reference electrode was placed in the tibial tuberosity, on the right side.[29]

For the collection of the electromyographic signal, the Miotool 400 (Miotec/Brasil) device was used, with 14-bit resolution, 5000-volt electrical isolation, 2000 Hz/channel sampling frequency common mode bounce rate 110 db, USB port for connection, with four channels, and connection to a laptop with Miographs software installed (Miotec, Brazil). The signal was treated using a Butterworth filter of fourth order and bandpass cutoff frequency between 20-450 Hz. The signals were cut to exclude delay between the start of the recording and execution of the handling, being the first and the last 2 s (in a total of 10 s) excluded,[18,21] and the root mean square (RMS) of the three muscles interest was calculated based on the 6 s of total.

Normalization using a maximum voluntary contraction (CMV) is commonly used for analysis of the EMG signal,[30] but in the target audience of this study most patients are unable to perform this type of contraction.[31,32] Therefore, the RMS was used, which assesses the level of EMG signal activity.[29] For each record, in all postures and muscles, the mean of the obtained EMG values was used.[30]

Sample calculation and statistical analysis

In order to detect an average effect size (Cohen's d = 0.5 or f = 0.25) for the difference between the three musculatures, with a power of 90% and significance level of $\alpha = 0.05$, the calculated sample was 36 patients. The software used for the calculation was GPower 3.1.9.

The results were obtained through a characterization of the sample, median and the 25th and 75th percentiles. The relative variation in handling, defined as the difference between handling and rest divided by rest, was compared between types of aid through tests for paired data, Wilcoxon test when there were two types of aid, and Friedman with Dunn's test for multiple comparisons in the case of three types and in the comparison between the muscles. At kneeling posture, values at rest were also compared between the muscles by the Friedman test. The analyses were performed using the SPSS software version 25 and were considered obtained when $p < 0.05$.

Results

The general characteristics of the two participating groups are described in Table 1; the data reinforces the severity of children and adolescents diagnosed with CP in this study.

Table 1 - Sample characterization

Variables	CP (n = 38)	Healthy (n = 20)
Age (median ± SD)	10,07 ± 4,4	10 ± 4,3
Gender		
Female	17 (44,7%)	11 (55%)
Male	21 (55,3%)	9 (45%)
GMFCS		
Level IV	15 (39,5%)	-
Level V	23 (60,5%)	-
Modified Ashworth Scale		
Degree 2	8 (21,1%)	-
Degree 3	24 (63,2%)	-
Degree 4	6 (15,8%)	-
Understand of commands	14 (36,8%)	-
Spastic muscles		
Harmstrings	18 (47,4%)	-
Adductor	15 (39,5%)	-
Quadriceps	3 (7,9%)	-
Others	6 (21,4%)	-
Use of gastrostomy and probe		
Gastrostomy	14 (36,8%)	-
Tracheostomy	1 (2,6%)	-

Note: CP = cerebral palsy; SD = standard deviation; GMFCS = Gross Motor Function Classification Scale.

Regarding Tables 2 and 3, the results presented through the median indicate the value of how much more the muscle activation varied during handling or during posture sustenance (Table 4) in comparison to resting.

Side-sitting handling

During handling in side-sitting, Table 2 shows a positive variation in muscle activation in relation to greater resting for the erector and gluteus medius in the CP group. For this same group, handling without the help of another therapist and with weight transfer was statistically significant. In the healthy group, there was significance in the variation of muscle activation for the gluteus medius and maximum. In order for the healthy group to be a reference, and for comparison purposes, during the handling in side-sitting there was a significant difference for the healthy group in relation to the CP, with the exception of the handling without the aid of another therapist and with weight transfer where there was no statistically significant difference between the groups.

Handling of rolling from prone to lateral decubitus position

During this handling, there was no statistically significant variation in muscle activation in relation to rest for any muscle in the CP group (Table 3). Only in the healthy group there was a significant difference for the erector muscle. Regarding variations in handling, there was also no significant difference for both groups. In the handling of rolling, the superiority of the variation of muscle activation for the healthy group is confirmed in relation to the CP group, in all handling situations.

Sustained kneeling posture

During the sustained kneeling posture, muscle activation was statistically significant for the erector and gluteus medius, but with greater variation for the erector muscle in the CP group (Table 4). In the healthy group, statistical difference was found only for the erector muscle. As for the intergroup comparison, there was a significant difference in muscle activation for both erector and gluteus medius.

Table 2 - Side-sitting handling and variations

Muscles activation	Healthy			Cerebral palsy			p-value (intergroup)
	P25	Median	P75	P25	Median	P75	
Erector							
With aid	40,39	73,61	160,38	-13,53	18,46	55,88	*0,002
Unaided and weight transfer	35,90	91,01	184,23	7,52	51,97	88,77	0,067
No weight transfer	19,21	55,88	233,51	-6,64	20,83	73,92	*0,036
p-value (variation between handlings)	0,638			#0,034			
GMED							
With aid	119,92	244,91	498,33	9,23	34,02	86,57	*0,000
Unaided and weight transfer	124,48	197,23	378,15	25,29	73,42	122,25	*0,000
No weight transfer	135,29	282,17	361,24	15,25	35,74	103,28	*0,000
p-value (variation between handlings)	0,287			0,191			
GMAX							
With aid	128,62	188,70	397,51	-0,06	24,22	54,15	*0,000
Unaided and weight transfer	154,59	217,55	388,60	9,25	45,95	124,97	*0,000
No weight transfer	79,96	147,78	232,66	10,54	49,00	111,70	*0,002
p-value (variation between handlings)	0,086			0,314			
p-value (muscle variation during handling with aid)	0,002			0,060			
p-value (muscle variation during unaided handling and with transfer)	0,060			$0,034			
p-value (muscle variation during handling without transfer)	0,015			0,006			

Note: Variation of muscle activation in relation to rest. Median values (P25-P75). *p-value between healthy and cerebral palsy groups; #p-value difference between higher handling for no aid and weight transfer, with significant activation for the erector muscle; $p-value variation of muscle activation to gluteus medius during unaided handling and weight transfer. Friedman with Dunn's test for multiple comparisons. Values expressed in microvolts.

Table 3 - Rolling handling and variations

Muscles activation	Healthy			Cerebral palsy			p-value (intergroup)
	P25	Median	P75	P25	Median	P75	
Erector							
With aid	15,00	101,01	377,01	5,39	36,27	78,34	*0,043
Without aid	109,42	202,42	444,02	-22,26	33,91	374,54	*0,025
p-value (variation between handlings)	0,100			0,157			
GMED							
With aid	58,34	162,72	352,95	11,10	60,53	165,93	*0,020
Without aid	84,40	189,28	416,92	10,91	48,66	191,81	*0,015
p-value (variation between handlings)	0,852			0,587			
GMAX							
With aid	51,56	147,41	259,96	0,99	46,64	146,83	*0,027
Without aid	41,22	83,24	259,74	-0,83	43,20	102,45	*0,050
p-value (variation between handlings)	0,765			0,365			
p-value (muscle variation during handling with aid)	0,449			0,607			
p-value (muscle variation during unaided handling)	0,043			0,710			

Note: Variation of muscle activation in relation to rest. Median values (P25-P75). *p-value between healthy and cerebral palsy groups. Wilcoxon test when there were two types of aid. Values expressed in microvolts.

Table 4 - Sustained kneeling posture

Muscles activation	Healthy			Cerebral palsy			p-value (intergroup)
	P25	Median	P75	P25	Median	P75	
Erector	5,97	7,53	12,15	8,67	12,12	19,20	*0,019
GMED	**3,00**	**3,65**	**5,63**	**4,76**	**8,29**	**15,13**	***0,001**
GMAX	2,83	3,85	6,27	2,99	5,91	9,48	0,202
p-value (muscle activation)		**0,000			**0,000		

Note: Muscle activation. *p-value between healthy and cerebral palsy groups; **p-value muscle activation for erector and gluteus medius CP group and erector group healthy. Friedman with Dunn's test for multiple comparisons. Values expressed in microvolts.

Discussion

The main objective of this study was to verify the activation of the erector muscles of the spine, gluteus medius and gluteus maximus, during the handling of the Bobath Concept and the sustained kneeling posture in children and adolescents with severe quadriparesis CP. The data show that muscle activation occurs for the erector and gluteus medius during handling in side-sitting with weight transfer and without the aid of another therapist, and greater activation for the erector occurs during the kneeling posture.

It is important to note that severe quadriparesis CP children are able to perform, even if with great difficulty, most daily activities in the sitting posture, as it offers greater stability and less degree of freedom to be controlled,[33] being of extreme importance the activation of trunk muscles for providing a better postural alignment and sustenance of the seated posture,[19,34] justifying the choice of the erector spine muscle in this study. The same can be applied to the gluteus medius and gluteus maximus muscles, which have the joint function of extending and abducting the hip,[32] movements so precarious in this population, contributing to altered patterns of movement over the lumbar spine, pelvic and hip region.[32,35-37] In relation to the chosen facilitation operations, they directly influence muscle tone through mobilization, stretching and activation of muscles through specific key points, facilitating postural control.[10] The sustained kneeling posture was chosen because it is widely used as a transition between handling in clinical practice.

To promote muscle activation, the Bobath Concept was the treatment choice, as it is the most used for individuals with CP.[19] It is a model of holistic and interdisciplinary clinical practice, which emphasizes individualized therapeutic handling, based on movement analysis.[16] It is based on key control points, such as elbow, wrist, hip and knee. Facilitation through these key points allows the conduction of movements, influences muscle tone, and improves alignment and self-organization of postural control.[38] The use of the hip join as the main control point can facilitate the necessary muscle torque,[17] so it was used during facilitation handling and in sustaining kneeling posture in this study.

One of the most common clinical symptoms in this population is severe spasticity, which can cause limitations in the performance of voluntary movements and result in inappropriate postures.[39] In the results presented, it is noteworthy that the majority of the research subjects were GMFCS V and the most spastic muscles were the hamstrings and hip adductors, corroborating some previous studies, such as Kim et al.[40] Evaluating the adductor and abductor muscles through electromyography, they managed to confirm that in the presence of spasticity, the tone of the adductor muscle becomes greater than that of the abductor, resulting in an inadequate position, where the lower limb is in adduction and internal rotation (posture in "scissors"), interfering in postural control maintenance.[40]

In order to directly imply in the improvement of postural control, specific muscles need to be activated and there are some strategies that can assist in this process. The transfer of body weight is one of them, serving as a basis to facilitate postural reactions and allowing patients better control by increasing muscle activity and developing motor skills.[41,42] It can also provide a plurality of sensory stimuli.[17] The positive effects of this facilitation can be found in the results of the present study, where the variation in muscle activity was greater during weight transfers in upper limbs in the wedge, with significant value during handling in side-sitting for the erector and gluteus medius. Daly et al.[32] also obtained positive results in the activation of the gluteus medius through specific strengthening exercises in a cross-sectional study with ten children diagnosed with CP.

Another important data found in our study was in relation to the assistance provided by a second therapist during the handling of side-sitting. It seems that without this assistance the participants in the CP group tend to activate more the analyzed muscles. Studies analyzing this fact are very scarce in the literature. Morgan et al.[13] emphasize that when movements are initiated by the children themselves along with task specification, the approaches are very promising. Therefore, this information can also be transferred to children even at the highest levels of the GMFCS and with the greatest constraints, thinking about what really needs to be facilitated for the patients, always trying to encourage them to reach their maximum level of activity within their limitations.

The muscle activation of the spine erector, verified in our study, was significantly greater in the sustained kneeling posture. In the study by Choi et al.[19] with ten diplegic children, there was also an increase in muscle activity of the erector both in the group that received Bobath therapy and in the group that received the task-oriented approach in order to improve the sitting posture. For the sustained kneeling posture, the CP group in our study had a greater variation than the healthy group; a possible explanation for this would be that the CP group does not present adequate postural control, in addition to the lack of selective motor control, and therefore oscillated during the sustained posture even with the help of the therapist. In addition, during posture maintenance, we observed several times that children entered an extensor pattern, due to increased tone. We are suggesting that the sustained kneeling posture is used for postural shifts in therapies or associated to a functional task when the patient collaborates or understands.

Regarding the handling of rolling, it seems that this was not enough to activate the analyzed muscles in a significant way, despite the values showing that muscle activation happened. In addition to this handling be performed in a horizontal plane and antigravity way, perhaps it can activate other muscles that were not evaluated in this study, such as the obliques, which contribute to the control of muscle activity and trunk stabilization.[43]

A confounding factor that can be found in this study, and therefore can be considered as a limitation, is attributed to spasticity, in terms of EMG values for some muscles. Spastic muscles exhibit exaggerated stretching reflexes, which contribute to the observed signal; however, this contribution depends on the state of the muscle (stretching, strength and/or its derivatives)[44] and can be managed by the treatment previously administered in participants. In our study, participants displayed elevated degrees in spasticity classification and an increase in tone during the execution of some movements. Pitto et al.[45] suggest removing these interferences from the spasticity of EMG signals; therefore, future studies should investigate this hypothesis. The pre-existing deformities in some participants, along with the increased tonus, was also a limiting factor when performing some movements since muscle shortening is secondary to hypertonia, but over time fixed contractures and deformities may develop,[46] contributing to the difficult handling of the most severe patients. In addition, regarding the profile of the sample of this study, even though they were classified according to the most severe levels of GMFCS, children and adolescents were very heterogeneous and presented varying degrees of motor impairments and complications secondary to the disease, determining their better or worse performance.

The collected signals are not immune to interference and to the interindividual variability of muscle volume and architecture, distribution, behavior and numbers of motor units within the range captured by the sensors, which may lead to variation in results.[32] In our study, the proper preparation of the skin, the use of filters for cleaning the signal, the adequacy of the environment, and the smoothing of data by the RMS were used to reduce external interferences.

Conclusion

Significant muscular activation of erector and gluteus medius was found when comparing rest and handling through the use of the Bobath Concept - through handling in side-sitting with weight transfer and without the aid of another therapist, and in the sustained kneeling posture The use of EMG was of great value for the evaluation of muscle activation in this study, being an easy to use and access tool. We recommend the clinical use of these handlings, so with their practice therapists can promote improvement of postural control and postural alignment, maintenance of the seated posture, and decision-making in physical therapy practice for the choice of an adequate and effective treatment in children and adolescents with severe spastic quadriparesis cerebral palsy. We encourage evidence-based practice with the available and most used treatments in the rehabilitation scenario, taking as an example the results of our study.

Authors' contribution

FZ and FC were responsible for the study conceptualization and, along with TP, for the data analysis and interpretation. FZ was also responsible for the manuscript writing, and BTP, BF and CCL for data collection. All authors approved the final version.

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