ORIGINAL ARTICLE

ISSN 0103-5150
Fisioter. Mov., Curitiba, v. 32, e003216, 2019
DOI: http://dx.doi.org/10.1590/1980-5918.032.AO16

Upper limb weight-bearing effect on the body alignment of individuals with cerebral palsy who have spastic hemiparesis: a randomized clinical trial

Efeitos da descarga de peso em membros superiores sobre o alinhamento corporal de indivíduos com paralisia cerebral do tipo hemiparesia espástica: ensaio clínico randomizado

Efectos de la descarga de peso en los miembros superiores sobre la alineación corporal de individuos con parálisis cerebral de tipo hemiparesia espástica: un ensayo clínico aleatorizado

Edlaine Aparecida Ribeiro de Oliveira, Lais Doratiotti Moraes, Juliana Firmo dos Santos, Márcia Harumi Uema Ozu, Maria Harue Misao, Lisa Carla Narumia*

Associação de Assistência à Criança Deficiente (AACD), São Paulo, SP, Brazil

Abstract

Introduction: Cerebral Palsy (CP) patients who have spastic hemiparesis usually present asymmetrical weight shift between the affected and non-affected side. **Objective:** To assess the effects of upper limb (UL) weight-bearing exercises on trunk symmetry, weight shift to the affected side and possible secondary effects on gait (speed and quality). **Method:** eleven participants with CP were randomized into two groups: Intervention Group (IG) and

* EARO: BS, e-mail: edi_earo@hotmail.com
LDM: BS, e-mail: lais.doratiotti.moraes@gmail.com
JFS: BS, e-mail: jsantos@aacd.org.br
MHUO: BS, e-mail: marciaozu@uol.com.br
MHM: BS, e-mail: aparecidariquie@gmail.com
LCN: BS, e-mail: lisanarumia@uol.com.br

Control Group (CG); IG (n = 6) performed stretching exercises of the major muscle groups of UL and lower limbs (LL) and UL weight-bearing exercises in prone and seated position for 12 weeks. The CG (n = 5) did not undergo any kind of motor therapy during the study period but received the same exercises that IG after the study. The variables analyzed were: Gross Motor Function Measure (GMFM-88); Pediatric Berg Scale; Trunk Impairment Scale (TIS); Six-minute walking test (6MWT); Ten meters walking test (10MWT); Timed Up & Go (TUG); Edinburgh Visual Gait Scale (EVGS); and ground reaction force. **Results:** The IG showed improvement on 6MWT, TUG, TIS and Pediatric Berg Scale (p < 0.01), and CG showed improvement on GMFM-88 (p < 0.04) only for the intragroup analysis. **Conclusion:** The exercises were effective to improve static and dynamic balance, increasing gait speed and identifying a trend of improvement on body alignment and weight shift to the affected side.

Keywords: Cerebral Palsy. Paresis. Upper Extremity.

Resumo

Introdução: *Pacientes com Paralisia Cerebral (PC) do tipo hemiparesia espástica, costumam apresentar transferência de peso assimétrica entre os hemicorpos.* ***Objetivo:*** *Avaliar os efeitos de um protocolo de exercícios de suporte de peso em membros superiores (MMSS) na simetria do tronco, transferência de peso para o hemicorpo afetado e possíveis efeitos secundários na marcha (velocidade e qualidade).* ***Método:*** *Onze participantes com PC foram randomizados em dois grupos: Grupo Intervenção (GI) e Grupo Controle (GC), o GI (n = 6) recebeu um protocolo de exercícios, composto por alongamentos dos principais grupos musculares de MMSS e membros inferiores (MMII), exercícios de suporte de peso em MMSS em prono e em sedestação, durante 12 semanas. O GC (n = 5) não realizou nenhum tipo de terapia motora durante à análise do estudo, mas após a finalização do estudo recebeu o mesmo protocolo que o GI. As variáveis analisadas foram: Medida da Função Motora Grossa (GMFM-88); Escala de Berg pediátrica; Escala de Comprometimento do Tronco (ECT); Teste de caminhada dos seis minutos (TC6); Teste de caminhada dos 10 metros (T10); Timed up and Go (TUG); Edinburgh Visual Gait Scale (EVGS) e reações do solo medidas por uma plataforma de força.* ***Resultados:*** *O GI evidenciou melhora no TC6, TUG, ECT e escala de Berg pediátrica (p < 0,01) e o GC apresentou melhora no GMFM-88 (p < 0,04), apenas na análise intragrupos respectivamente.* ***Conclusão:*** *O protocolo foi efetivo no equilíbrio estático e dinâmico, aumentando a velocidade da marcha e apresentando uma tendência na melhora do alinhamento corporal e transferência de peso para o hemicorpo afetado.*

Palavras-chave: *Paralisia Cerebral. Paresia. Extremidade Superior.*

Resumen

Introducción: *Los pacientes con parálisis cerebral (PC) de tipo hemiparesia espástica suelen presentar un traslado de peso asimétrico entre los hemicuerpos.* ***Objetivo:*** *Evaluar los efectos de un protocolo de ejercicios de soporte de peso en miembros superiores (MMSS) en la simetría del tronco, el traslado de peso al hemicuerpo afectado y los posibles efectos adversos en la marcha (velocidad y calidad).* ***Método:*** *Participaron 11 individuos con PC, siendo aleatorizados en dos grupos: Grupo Intervención (GI) y Grupo Control (GC); el GI (n=6) recibió un protocolo de ejercicios, que constaba de estiramientos de los principales grupos musculares de MMSS y miembros inferiores (MMII), y de ejercicios de soporte de peso en MMSS en prono y en sedestación, durante 12 semanas. El GC (n=5) no realizó ningún tipo de terapia motora durante el análisis del estudio, pero después de finalizado el estudio recibió el mismo protocolo que el GI. Las variables analizadas fueron las siguientes: Medida de la Función Motora Gruesa (GMFM-88); Escala Pediátrica de Berg; Escala de Compromiso del Tronco (ECT); Test de caminata de los seis minutos (TC6); Test de caminata de los 10 metros (T10); Timed up and Go (TUG); Edinburgh Visual Gait Scale (EVGS); y las reacciones del suelo medidas mediante una plataforma de fuerza.* ***Resultados:*** *En el GI se observó una mejora en el TC6, TUG, ECT y Escala Pediátrica de Berg (p<0,01); y en el GC hubo una mejora en el GMFM-88 (p<0,04), solo en el análisis intragrupal.* ***Conclusión:*** *El protocolo presentó una efectividad para el equilibrio estático y dinámico, aumentando la velocidad de la marcha y posibilitando una tendencia de mejora de la alineación corporal y traslado de peso en el hemicuerpo afectado.*

Palabras clave*: Parálisis Cerebral. Paresia. Extremidad Superior.*

Introduction

The upper limb (UL) weight-bearing capacity on normal motor development is an important factor for children to acquire new skills. Its results can be identified after the second quarter of the first postnatal year, when the child already has some control of the movement against gravity in the prone position. In this position, there is a greater involvement of the trunk muscles and UL bearing in an attempt to lift it from the bearing surface [1, 2].

Important movements are acquired for normal motor development from the prone position, such as pivoting, creeping, followed by crawling, and UL bearing helps the baby sit alone. Weight-bearing components in prone position, in four supports and during crawling, act as an important stability point for the shoulder girdle and trunk [1, 3].

In contrast, children with Cerebral Palsy (CP) present movement and posture disorders that affect their functional activities due to nonprogressive disturbances that occur during fetal or infant brain development [4]. Therefore, the motor development steps in children with CP are atypical, showing a delay and abnormal progress [5, 6].

In children with hemiparetic CP, sensory motor changes are found in one of the sides of the body, resulting in the lack of shoulder girdle and trunk control on the affected side, difficulty in reciprocal movements and body weight shift [4, 5].

Specific UL weight-bearing exercises are able to prevent muscle shortening, improve bone growth, mineral density, the stability of shoulder girdle and trunk and, consequently, the function, acting on the limitations of the abnormal development. However, there are few reports on the benefits of weight-bearing exercises and their influence on trunk symmetry and weight shift to the affected side [7, 8].

The main objective of this study was to assess the potential benefits of UL weight-bearing exercises on trunk symmetry (static and dynamic balance) and weight shift to the affected side and, secondarily, to observe whether the exercises would influence gait speed and/or quality, given that the literature on the interference of UL movements on gait does not present a consensus.

Method

This is a controlled, randomized, prospective and longitudinal clinical trial. The study was conducted with volunteers from a single center. It was approved by the Research Ethics Committee of the Assistance Association for Disabled Children (AACD) under opinion no.: 1,179,055 and authorized by the person responsible for the participant via informed consent form. The study was conducted in the Physical therapy sector of AACD – Ibirapuera/São Paulo.

Casuistry

The search for CP patients of the clinic who were being treated at the institution was conducted from February to April 2015. Children and adolescents underwent a phone screening to verify which of them met the inclusion criteria, which were: 1) Individuals of both sexes; 2) Age group between 7 and 15 years; 3) Diagnosis of spastic hemiparesis; 4) Classified as level I in Gross Motor Function Measure (GMFCS), i.e., young people who use gait as a functional way to move around the house, the school and the community without additions [9]; 5) Those not undergoing Physical therapy, Occupational therapy or Aquatic physical therapy and 6) Those able to obey simple commands.

Individuals with clinical instability that hindered the implementation of the exercises, who had undergone some sort of orthopedic surgeries and/or neuromuscular blocking for less than six months, and those who were not available to attend the institution twice a week were excluded.

The search included 119 individuals, but 106 individuals were excluded based on the inclusion criteria. Therefore, a simple random sample was completed with 13 participants (Figure 1), i.e., participants were randomly divided into two groups by a single responsible professional.

The Intervention Group (IG) was submitted to UL weight-bearing exercises developed in this study for 12 weeks. The Control Group (CG) did not undergo any kind of motor therapy during the study period but after the study, the same exercise protocol was applied to it.

Sample power was calculated using G*Power by considering the mean and standard deviation (SD) of the IG. A *post hoc* paired T-test analysis (intragroup analysis) was conducted, the appropriate power was $\beta \geq 0.80$ with $\alpha=0.05$. The tests that showed these results were Six-minute walk test (0.84) and trunk impairment scale (0.84), and timed Up & Go was close to the appropriate value (0.70).

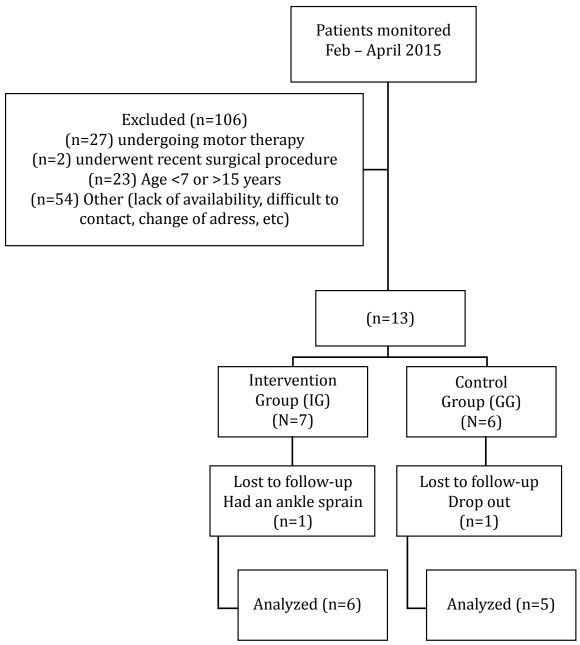


Figure 1 – Flowchart of the selection process of the study participants.

Procedures

For sample characterization, the individuals selected were classified according to the upper limb function considering the Manual Ability Classification System (MACS), a scale used to measure the manual ability when handling an object [10]. This classification was used to compare the manual skills among the participants. In addition, the length between UL and lower limbs (LL) was measured to identify discrepancies between them.

Subsequently, the following assessment tools were submitted to pre- and post-treatment, performed by two independent assessors who did not had access to the randomization, i.e., they did not know in which group the individuals were:

Gross Motor Function Measure (GMFM-88) assesses the performance of children and adolescents in five motor dimensions: lying and rolling; sitting; crawling and kneeling; standing; and walking, running, and jumping [11].

Balance assessment was made by the Pediatric Berg Balance Scale, divided into 14 items, with maximum score of 56 points, in which each item had an ordinal scale of five alternatives that range from zero to four points [12, 13].

Trunk Impairment Scale (TIS) consists of 17 items grouped into three subscales: static balance, dynamic balance and coordination in sitting position. The total score of TIS ranges from 0 to 23 (from worst to best trunk function) [14].

Six-minute walk test (6MWT), in which the patients are asked to walk for six minutes in a hallway to assess physical fitness and functional mobility. This test has shown good reliability among assessors for its application in children and adolescents with CP [15, 16].

Ten-meter walk test (10MWT) assesses the maximum speed covered for a distance of ten meters, but it has not been validated for children with CP [17].

Timed Up & Go (TUG) assesses the mobility and balance in the walk, it has already been validated for the studied population, being a sensitive test to verify functional changes [18, 19].

Edinburgh Visual Gait Scale (EVGS) is composed of 17 parameters for each lower limb assessed at six anatomical levels: trunk, pelvis, hip, knee, ankle and foot. The parameters were assessed through the observation of videos [20, 21].

To calculate the UL weight-bearing capacity, ground reaction forces were recorded using two force platforms present in the AACD Gait Laboratory – model 0R6-5-1000 of Advanced Mechanical Technology Inc (AMTI), 46.5 x 50.5 cm dimensions. The software used for data collection was Qualisys Track Manager (QTM) version 2.8 of Qualisys AB.

A pressure mapping sensor® assessed the difference of body weight shift in sitting position.

At the end of the reassessments of the IG, the responsible person for the participant answered a form, describing the changes that occurred during the 12 weeks.

Intervention

Individuals included in the IG performed the UL weight-bearing exercises for 12 weeks of physical therapy. Each session lasted 40 minutes and occurred twice a week, with intervals of at least one day between each session. Individuals included in the CG did not perform any kind of motor therapy during data collection. After the project ended, the same protocol was offered to these individuals.

Two physical therapists were responsible for the application of the protocol to the IG, described below:

a) *Global stretches (conducted passively):*

- Of the following muscles: pectoral, triceps and biceps brachii, hamstring, tibialis anterior,

adductor and internal hip rotator, bilaterally and holding the position for 30 seconds each.
- Individuals with CP may present increased muscle tone, which increases the chance of developing muscle shortenings, and this may interfere with the correct positioning for the completion of the exercises.

b) *UL weight-bearing exercises in prone position:*

- Through the support of the unilateral forearm, the participant began the reaching activity by crossing the midline, with ten repetitions on each upper limb.
- Using stabilizers for elbow extension (canvas splints), the child began the activities with the support of distal UL in five different situations: in the first, the support was on an inclined plane, requiring the extension of UL and upper trunk, three series of ten repetitions; in the second, support was on a flat surface, holding isometrics for three sets of ten seconds; in the third, unilateral support was on a flat surface, requiring lateral reach, ten repetitions on each upper limb; in the fourth, a sliding – flexion/extension of the shoulder – activity was requested on unstable surface for three sets of ten repetitions, and in the fifth activity, the child rested the UL on the ground, while the LL were sustained by the therapist, and covered a distance of four meters.

c) *UL weight-bearing exercises in seated position:*

- Seated, the child began the flexion exercise and shoulder horizontal activity on an anterior stable surface, unilaterally, performing five repetitions for each movement.
- Starting from distal UL support on a stable surface with extension and external rotation of shoulders and scapular adduction, the child began the pelvic lift exercise. Three sets of five repetitions were held.

Statistical analysis

The normality of data was verified by a parametric Kolmogorov-Smirnov test, it was used to analyze the quantitative variables of the sample considering mean and SD. To assess the effect of the intervention, Student's t-test for paired samples was used to evaluate intragroup results and non-paired results for intergroup analysis.

For all tests, $p = 0.05$ (*) ($\alpha \leq 5\%$) levels were fixed as statistically significant.

Results

The sample was composed of 11 participants, the characteristics of these participants are listed in Table 1.

Table 1 – Sample characterization

		IG (n = 6)	CG (n = 5)
Age in years (SD)		8 (±2)	9 (±3)
Sex (%)	Female Male	5 (83) 1 (17)	3 (60) 2 (40)
Topography (%)	Right-sided Hemiparesis	3 (50)	2 (40)
	Left-sided Hemiparesis	3 (50)	3 (60)
Orthosis (%)	Uses Does not use	5 (83) 1 (17)	3 (60) 2 (40)
Type	Articulated Ankle-foot	4 1	1 2
MACS (%)	I	100	100
Discrepancy between limbs (%) (participants who have it)	UL	6 (100)	3 (60)
	LL	6 (100)	4 (80)

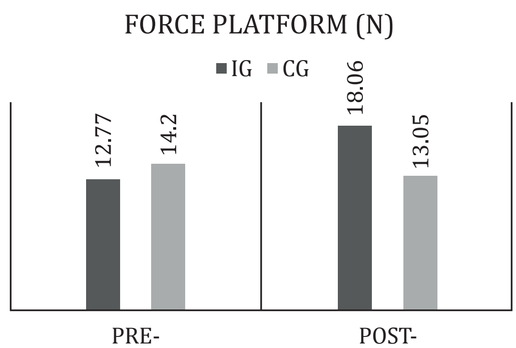
Intergroup analysis showed no statistical difference in any of the scales applied to the study. Considering only the intragroup results, the IG showed significant changes when compared to the pre-treatment in 6MWT, TUG, TIS and Berg, since the CG only showed difference in GMFM-88 (Table 2).

In the force platform, the UL weight bearing was analyzed only on the affected side between both groups, the IG showed increased support after the exercises ($p < 0.10$), while the CG showed decreased support ($p < 0.25$). However, these data were not statistically significant for any group (Figure 2). We also analyzed the weight-bearing between the sides of the body of the IG (Figure 3). The mean of the weight-bearing for the affected side was smaller for left hemiparetic patients, but these data also showed no significant differences.

Table 2 – Description of intragroup means pre- and post-treatment

	Mean (SD)															
	6MWT pre- (m)	**6MWT post- (m)**	**10MWT pre- (sec)**	**10MWT post- (sec)**	**TUG pre- (sec)**	**TUG post- (sec)**	**TIS pre- (total)**	**TIS post- (total)**	**Berg pre- (total)**	**Berg post- (total)**	**GMFM-88 pre- (%)**	**GMFM-88 post- (%)**	**Sensor® pre- (mmhg)**	**Sensor® post- (mmhg)**	**EVGS pre- (total)**	**EVGS post- (total)**
IG	375.00 (27.93)	441.58 (50.57)	7.29 (1.38)	6.66 (0.63)	9.42 (1.81)	7.41 (0.70)	9.83 (1.33)	17.67 (2.66)	51.83 (3.54)	54.17 (2.56)	97.76 (1.86)	98.46 (1.02)	62 (26)	56 (24)	8 (4)	7 (4)
p-value		**0.01**		0.20		**0.01**		0.00		**0.01**		0.13		0.58		0.17
CG	434.74 (44.31)	449.50 (17.36)	6.97 (1.03)	6.95 (1.24)	12.01 (9.33)	7.17 (0.45)	17.40 (2.07)	18.40 (2.07)	53.60 (1.95)	54.00 (2.00)	97.34 (2.39)	98.09 (1.96)	65 (8)	45 (18)	6 (6)	5 (5)
p-value		0.60		0.95		0.30		0.30		0.18		**0.04**		0.09		0.48

Note: m = mean; sec = seconds.



Note: N=Newton

Figure 2 – Mean of the weight-bearing on the affected upper limb, by the force platform between the groups.

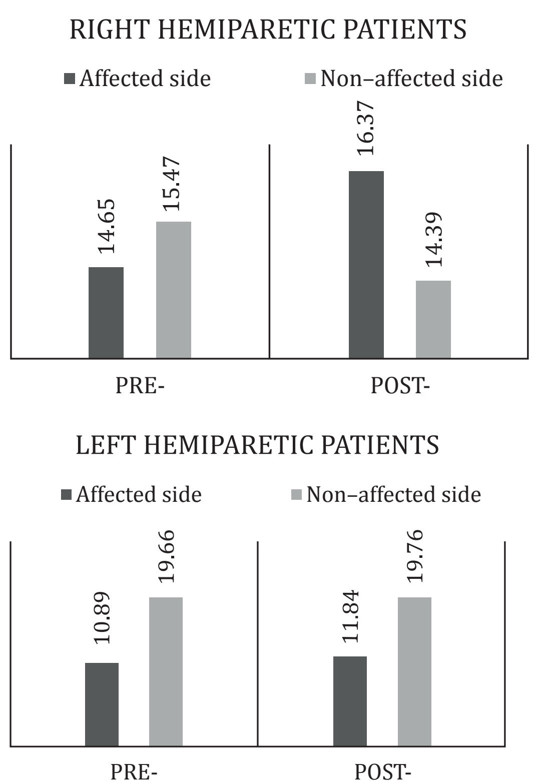


Figure 3 – Mean of UL weight-bearing between the sides of the body of the IG, by the force platform.

Discussion

This study used the UL weight-bearing exercises in an attempt to improve the trunk symmetry and the weight shift to the affected side in cerebral palsy patients. Although the study did not show a statistically significant difference in the intergroup analysis, the IG obtained some positive results, showing that UL weight-bearing exercises influence the balance and speed of gait in some way.

Upper limbs weight-bearing during motor development is crucial for the acquisition of shoulder girdle stability and greater trunk control. When in prone position, a child uses the arm extension to reach toys by shifting the weight to the contralateral side of the body. This period is characterized by body symmetry, with varying motor patterns and large mobility in supine and prone positions. This is due to the increase in postural reactions and to the acquisition of sagittal and transverse planes, providing shifts and dissociations [1, 3].

Furthermore, weight-bearing also influences as a non-nutritional factor on weight and height development [22]. Zonta [23] analyzed the growth and anthropometry in hemiparetic CP patients and observed changes in this population growth, especially when referring to the discrepancy between the sides of the body and the cephalic perimeter. This was also observed in our study. The measurements showed length discrepancy between limbs, the limbs of the affected side are relatively smaller than the limbs of the non-affected side. The compromised weight-bearing capacity in patients causes the length discrepancy of limbs, which, in turn, worsens the asymmetry in weight distribution. This situation creates a cycle in which identifying the cause and effect is difficult.

In the force platform, when comparing the mean weight-bearing percentage between the sides of the body of the IG, left hemiparetic patients showed lower weight-bearing means on the affected side, both in pre- and post-treatment, these data were not statistically significant, but show an asymmetric weight in these individuals. Gazzaniga focused his research on the functions of the right hemisphere of the brain and suggested that this hemisphere is specialized for handling and processing special motor aspects [24]. This result suggests that perceptual issues can negatively influence the weight shift of hemiparetic muscles of the left side and that this is a population that needs to be better monitored during treatment.

Regarding the proposed objectives for gait, the 6MWT results were only significant for the IG, i.e., the participants who received the weight-bearing exercise protocol increased the distance covered measured by the test. This result was also found in TUG, which in addition to assessing the functional mobility, assesses the risk of falls and dynamic balance. We believe this is the result of improved stability in the trunk muscles, favoring biomechanical alignment with greater extent of the upper limb and integration as a support base in dynamic balance, as studies show that the movements of the upper limbs during walking help in maintaining balance, controlling the movement of the center of mass and also results in smaller energy expenditure in the LL [25, 26].

Through his review study, Nicolini Panisson [27] showed that TUG was a good instrument to assess the functional mobility and correlated with other balance tests, such as the Berg scale and gait speed test. Our results corroborate these findings since participants showed improvement in balance and, consequently, increased the distance covered measured by 6MWT.

In this study, individuals in the IG showed improvement in static and dynamic areas of TIS, which may have resulted in better trunk control during walking. The study by Saether [28] showed good correlation on trunk control during walking using TIS. According to Carvalho [29] and Heyrman [30], the efficiency of postural control is critical for the success of many daily tasks, including walking.

Chaudhuri [31] reports that, in patients with spastic hemiparesis, asymmetry interferes with the ability to maintain postural control, hindering the stability to make movements and causing trunk imbalance, which may lead to falls. This study found significant improvement on the Pediatric Berg Scale in the IG, which may be related to the training protocol since we prioritized exercises to improve the weight distribution on both UL, thus providing a better weight distribution on both sides of the body and offering greater stability.

Regarding GMFM-88, no significant difference was found in the intergroup analysis, but a difference was observed in the intragroup analysis for the CG. This result is not clear since this scale measures possible quantitative changes and was not observed in other scales for this same group.

The results obtained in the final measures presented in our study were consistent with the information provided by the parents and caregivers after the study period ended. These individuals reported better body alignment, improved weight distribution on the LL and static balance in orthostatism and dynamic balance during walking, which consequently decreased the number of falls these patients suffered.

This study presents important limitations such as: the small sample size; the lack of application of a potentially more sensitive scale in terms of post-intervention changes, whether to measure possible gains in activities of the daily living or qualitatively measure the gross motor function by applying the Quality Function Measure [32] for example; the absence of a control group undergoing conventional therapy to confirm that the results obtained in this study were due to the exercises;, and the lack of a crossover and a follow-up to monitor the maintenance and/or changes of these results.

Conclusion

The UL weight-bearing exercises conducted in this study presented favorable results in the improvement of body alignment and weight shift to the affected side of the body, promoting better balance in dynamic and static situations and improving gait speed.

Further studies are needed to show the effectiveness of these exercises in gait quality, as well as larger samples and other specific tests for this type of assessment.

References

1. Tecklin JS. Fisioterapia pediátrica. Porto Alegre: Artmed; 2002.

2. Gallahue DL. Compreendendo o desenvolvimento motor: bebês, crianças, adolescentes e adultos. São Paulo: Phorte; 2003.

3. Bly L. Motor skill acquisition in the first year: an illustrated guide to normal development. Tucson: Therapy Skill Builders; 1994.

4. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax MA, Damiano D, et al. A report: the definition and classification of cerebral palsy. Dev Med Child Neurol. 2007;49(6):480.

5. Bobath B, Bobath K. Desenvolvimento motor nos diferentes tipos de paralisia cerebral. São Paulo: Manole; 1989.

6. Bobath K. A deficiência motora em pacientes com paralisia cerebral. São Paulo: Manole; 1979.

7. Braendvik SM, Elvrum AK, Vereijken B, Roeleveld K. Relationship between neuromuscular body functions and upper extremity activity in children with cerebral palsy. Dev Med Child Neurol. 2010;52(2):29-34.

8. Pin TW. Effectiveness of static weight bearing exercises in children with cerebral palsy. Pediatr Phys Ther. 2007;19(1):62-73.

9. Palisiano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol. 1997;39(4):214-23.

10. Eliasson AC, Krumlinde-Sundholm L, Rösblad B, Beckung E, Arner M, Öhrvall AM, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. Dev Med Child Neurol. 2006;48(7):549-54.

11. Russell DJ, Rosenbaum PL, Avery LM, Wright M. Gross motor function measure (GMFM-66 & GMFM-88): user´s manual. London: Mac Keith Press; 2002.

12. Ries L, Michaelsen S, Soares P, Monteiro V, Allegretti K. Adaptação cultural e análise da confiabilidade da versão brasileira da Escala de Equilíbrio Pediátrica (EEP). Rev Bras Fisioter. 2012;16(3):205-15.

13. Iatridou G, Dionyssiotis Y. Reliability of balance evaluation in children with cerebral palsy. Hippokratia. 2013;17(4):303-6.

14. Castellassi CS, Ribeiro EAF, Fonseca VC, Beinotti F, Oberg TD, Lima NMFV. Confiabilidade da versão brasileira da escala de deficiências de tronco em hemiparéticos. Fisioter Mov. 2009;22(2):189-99.

15. Britto RR, Sousa LAP. Teste de caminhada de seis minutos uma normatização brasileira. Fisioter Mov. 2006;19(4):49-54.

16. Oeffinger D, Gorton G, Hassani S, Sison-Williamson M, Johnson B, Whitmer M, et al. Variability explained by strength, body composition and gait impairment in activity and participation measures for children with cerebral palsy: a multicentre study. Clin Rehabil. 2014;28(10):1053-63.

17. Thompson P, Beath T, Bell J, Jacobson G, Phair T, Salbach NM, et al. Test-retest reliability of the 10-metre fast walk test and 6-minute walk test in ambulatory school-aged children with cerebral palsy. Dev Med Child Neurol. 2008;50(5):370-6.

18. Williams EN, Carroll SG, Reddihough DS, Pphillips BA, Galea MP. Investigation of the timed 'up & go' test in children. Dev Med Child Neurol. 2005; 47(8):518-24.

19. Campos AC, Costa CS, Rocha NA. Measuring changes in functional mobility in children with mild cerebral palsy. Dev Neurorehabil. 2011;14(3):140-4.

20. Read HS, Hazlewood ME, Hillman SJ, Prescott RJ, Robb JE. Edinburgh visual gait score for use in cerebral palsy. J Pediatr Orthop. 2003;23(3):296-301.

21. Bella GP, Rodrigues NB, Valenciano PJ, Silva LM, Souza RC. Correlation among the visual gait assessment scale, Edinburgh visual gait scale and observational gait scale in children with spastic diplegic cerebral palsy. Rev Bras Fisioter. 2012;16(2):134-40.

22. Stevenson RD, Hayes RP, Cater LV, Blackman JA. Clinical correlates of linear growth in children with cerebral palsy. Dev Med Child Neurol. 1994;36(2):135-42.

23. Zonta MB, Agert F, Muzzolon SRB, Antoniuk SA, Magdalena NIR, Bruck I, et al. Growth and anthropometry in hemiplegic cerebral palsy patients. Rev Paul Pediatr. 2009; 27(4): 416-23.

24. Gazzaniga MS. Two brains: my life in science. In Rabbitt P, editor. Inside Psychology: a science over 50 years. Oxford: Oxford University Press; 2009. p. 101-16.

25. Kavanagh JJ, Barrett RS, Morrison S. Upper body accelerations during walking in healthy young and elderly men. Gait Posture. 2004;20(3):291-8.

26. Hodges PW, Cresswell AG, Daggfeldt K, Thorstensson A. Three dimensional preparatory trunk motion precedes asymmetrical upper limb movement. Gait Posture. 2000;11(2):92-101.

27. Nicolini-Panisson RD, Donadio MVF. Timed "up & go" test in children and adolescents. Rev Paul Pediatr. 2013;31(3):377-83.

28. Saether R, Helbostad JL, Adde L, Braendvik S, Lytdersen S, Vik T. The relationship between trunk control in sitting and during gait in children and adolescents with cerebral palsy. Dev Med Child Neurol. 2015;57(4):344-50.

29. Carvalho RL, Almeida GL. Aspectos sensoriais e cognitivos do controle postural. Rev Neurocienc. 2009;17(2):156-60.

30. Heyrman L, Feys H, Molenaers G, Jaspers E, Monari D, Meyns P, et al. Three-dimensional head and trunk movement characteristics during gait in children with spastic diplegia. Gait Posture. 2013;38(4):770-6.

31. Chaudhuri S, Aruin AS. The effect of shoe lifts on static and dynamic postural control in individuals with hemiparesis. Arch Physical Med Rehabil. 2000; 81(11):1498-503.

32. Wright V, Rosenbaum P, Fehlings D, Mesterman R, Breuer U, Kim M. The Quality Function Measure: reliability and discriminant validity of a new measure of quality of gross motor movement in ambulatory children with cerebral palsy. Dev Med Child Neurol. 2014;56(8):770-8.

Received in 08/29/2018
Recebido em 29/08/2018
Recibido en 29/08/2018

Approved in 02/18/2019
Aprovado em 18/02/2019
Aprobado en 18/02/2019