Case Report

Linear parameters of the march of children with cerebral palsy of the spastic type: case study

Parâmetros lineares da marcha de crianças com paralisia cerebral do tipo espástica: estudo de caso

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ABSTRACT | INTRODUCTION: Cerebral palsy (CP) occurs due to injury to the central nervous system resulting in functional impairment and gait changes. **OBJECTIVE:** To verify and describe the linear gait variables of children with static cerebral palsy. **MATERIALS AND METHODS:** Three children aged between six and seven years with spastic cerebral palsy, GMFCS level I and II participated in the study, where the performance of gross motor function was identified by means of the Thick Motor Function Classification System (GMFSC) with grades 3 and 4 of spasticity in the lower limbs according to the Modified Ashworth Scale (MAS). To record the linear parameters and data organization, the cvmob free software and the motion movement - Movement Element Decomposition method were used. **RESULTS:** The values found for speed were (0.64; 0.58; 0.96 m / s) step length (0.34; 0.36; 0.36 m) cadence (127; 118; 130 p / min). **CONCLUSION:** There was a reduction in linear gait variables for speed, length and cadence in the three children studied. Despite the difficulty in obtaining larger samples, the data suggest the need for greater control of gait variables in children with spastic cerebral palsy.

KEYWORDS: Cerebral palsy. Gait. Motor disturbances. Biomechanical phenomena.

RESUMO | INTRODUÇÃO: A paralisia cerebral (PC) ocorre devido lesão no sistema nervoso central, resultando em comprometimento funcional e alterações na marcha. **OBJETIVO:** Verificar e descrever as variáveis lineares da marcha de crianças com paralisia cerebral do tipo espástica. **MATERIAIS E MÉTODOS:** Participaram do estudo três crianças com idade entre seis e sete anos com paralisia cerebral do tipo espástica, GMFCS nível I e II, onde foi realizada a identificação do desempenho da função motora grossa por meio do Sistema de Classificação da Função Motora Grossa (GMFSC) com grau 3 e 4 de espasticidade em membros inferiores segundo a Escala Modificada de *Ashworth* (MAS). Para registro dos parâmetros lineares e organização dos dados foram utilizados o software livre CVMob e o método de análise de movimento MED - *Movement Element Decomposition*. **RESULTADOS:** Os valores encontrados para velocidade foram (0,64; 0,58; 0,96 m/s) comprimento do passo (0,34;0,36; 0,36 m) cadência (127; 118; 130 p/min). **CONCLUSÃO:** Foi verificada a diminuição das variáveis lineares da marcha para velocidade, comprimento do passo e cadência nas três crianças estudas. Apesar da dificuldade em obter amostra maior, os dados sugerem a necessidade de maior controle das variáveis da marcha de crianças com Paralisia cerebral do tipo espástica.

PALAVRAS-CHAVE: Paralisia cerebral. Marcha. Distúrbios motores. Fenômenos biomecânicos.

Submitted 05/28/2020, Accepted 08/01/2020, Published 08/19/2020
J. Physiother. Res., Salvador, 2020 August;10(3):529-536
Doi: 10.17267/2238-2704rpf.v10i3.2992 | ISSN: 2238-2704
Designated editors: Cristiane Dias, Katia Sá, Sumaia Midlej

How to cite this article: Magalhães PHS, Oliveira JGS, Santos VS, Bião MAS. Linear parameters of the march of children with cerebral palsy of the spastic type: case study. J Physiother Res. 2020;10(3):529-536. doi: 10.17267/2238-2704rpf.v10i3.2992

Introduction

The neurological injuries that occur in childhood when the brain is in the stage of development and maturation, cause changes in the nervous system that can result in chronic non-progressive encephalopathy also known as cerebral palsy (CP), which is characterized by the presence of stationary disorders, causing disorders in the child's motor development, deeply limiting its functionality[1].

It is estimated that its incidence in developed countries is 2.0 to 2.5 per 1000 live births, whereas in developing countries it is 7/1000 live births[2]. In Brazil, there are approximately 30,000 to 40,000 new cases per year, in 70% to 80% of cases, cerebral palsy occurs in the prenatal period due to several factors, including congenital malformations, infections during pregnancy, hypoxemia, abdominal trauma, prematurity and low weight[1,2].

The clinical manifestations of cerebral palsy vary according to the affected brain area (cerebellum, cerebral cortex, base nuclei), its etiology is classified as ataxic, extrapyramidal, spastic and mixed. Topographic characteristics are divided into diparesis, quadriparesis and hemiparesis[1]. Spastic cerebral palsy corresponds to 70% of cases, affecting the musculoskeletal system, causing an increase in muscle tone with a pathological pattern in the reciprocity of inhibition of antagonistic muscles, generating excessive muscle coactivation, reinforcing functional impairment[1,3].

Gait is the most affected function in spastic cerebral palsy, it allows the transfer from one place to another. The normal gait pattern consists of cycles that are passed when the heel that touched the ground touches it again and the step that is the distance between the two heels[4]. The phases it composes are: initial contact, the support phase, (initial, medium, final,) balance phases, (initial, medium and final), to proceed with a new cycle[5].

Due to the presence of spasticity compromising muscle function, excess plantar flexion, known as the echinovaro foot, alters the position of the limb and modifies the gait cycle[6]. This causes balance changes that, to ensure stability and gait, compensatory movements are observed to maintain a safe pattern of locomotion[1]. These modifications, despite being the best solution found to perform locomotion, represent a risk for the appearance of shortening, contractures and possible deformities that alter and impair the gait dynamics[6].

Considering that walking is an important motor skill for displacement and functional independence, involving discharges and weight transfers in the limbs, it is important to identify the changes present to define the existing changes. Thus, the aim of this study was to verify and describe the linear gait variables of children with spastic cerebral palsy.

Methods

A quasi-experimental research, also known as non-random experiments, was carried out, in which the research group in question is analyzed without and with some type of intervention.

This study was carried out at the Association of Parents of Friends of the Exceptional (APAE) of Feira de Santana-Bahia, located at Rua São Cosme e Damião, Bairro Santa Mônica. In turn, it is a civil, philanthropic, charitable, educational, cultural, health, study and research, non-profit association that provides educational assistance to children and adolescents with disabilities.

The study included children with spastic cerebral palsy, aged between 6 and 7 years, classified in levels I and II of the Gross Motor Function Classification System (GMFCS) with the ability to attend to simple verbal commands such as “standing, walking , stop, turn around ”.

Those with multiple hearing, visual, and intellectual disabilities were excluded from the study; discrepancy of lower limbs; hip dysplasia; those who underwent surgical procedures in the last 12 months and / or application of botulinum toxin and phenol in the last six months before data collection, as well as those who presented degrees 3 and 4 of lower limb spasticity, according to the Modified Scale of Ashworth. Authorization was requested from the parents or guardians of the children by signing the Informed Consent Form.

To assess motor function, thescale was used Gross Motor Function Classification System (GMFCS), which classifies the child's gross motor function into levels with an emphasis on the movement of sitting and walking through five motor levels present in each of the four age groups (0 to 2 years, 2 to 4 years, 4 to 6 years and 6 to 12 years). The levels are ordinally classified as: Level 1: walks without restrictions, has limitations in more complex motor activities. Level 2: Walks without restrictions, presents difficulties in the environment and in the community Level 3: walks with auxiliary resources, limitations in the environment Level 4: have mobility limitations, need to be transported, use mobility resources. Level 5: Mobility severely affected, needs Assistive Technology resources[7].

The degree of spasticity of children was assessed using the Modified Ashworth Scale (MAS), which is a 6-point scale and aims at precision related to the assessment of tone, quantifying the passive resistance of the musculature. The MAS points are: 0: Normal tone, 1: Little increase in muscle tone, with resistance at the end of ROM, when the parts that were affected are moved in flexion and extension, 1+: Little increase in tone, referred to by apprehend, with minimal resistance through less than half, the range of motion, 2: Notable increase in muscle tone, through a greater range of motion, but the affected parts exercise movements easily, 3: Relevant increase in tone, with impaired passive movements. 4: The affected part presents rigidity in the flexion or extension movements[8].

The first step of the gait analysis corresponded to the adaptation of the participants by 3 meters in a straight line, in the place destined for the collection of gait at a selected auto speed. After adaptation to the collection site, the reflective markers were fixed at the following anatomical points: left thigh (greater trochanter), left knee (lateral condyle), left ankle (lateral malleolus) and the 5th left toe, as it is the limb affected in the selected children.

To capture the kinematic data, a wide location was selected, with good lighting and a flat surface without irregularities, a Nikon p510 camera, a tripod for fixing the camera and stickers developed by the researchers were used to mark the child's anatomical points. They were asked to perform the march, with 6 steps, so that 3 were captured for analysis.

The gait analysis consisted of taking steps in the assessment environment, where participants performed the same route as the adaptation session in 7 attempts, until 6 steps were fully captured. Participants performed the bare feet analysis. The present study followed the parameters of gait normality and the space-time variables of speed, cadence and step length proposed by Dusing, Thorpe[9].

To carry out this research, an analysis was made of the risks that could be taken to the subject or guardian, such as: discomfort, due to the professionals' monitoring of the child for data collection, embarrassment to parents and / or guardians in answering the questionnaire, expectation and / or anxiety and fall during gait.

In order to minimize these risks, the presence of parents and / or guardians was essential, the place used for the analysis was properly lit, with a dry floor and a flat surface, with no objects or unevenness that could offer the greatest risk of falling, and team was present at all times to provide safety for the child and guardians. The benefits of this research included: accessibility, inclusion, highlighting the importance of physical therapy follow-up and an accurate biomechanical assessment in relation to the use of an appropriately adequate device to reduce the risk of falls and deformities.

The analysis of the results was performed according to descriptive statistics (absolute / relative frequency) in order to identify the general and specific characteristics of the studied sample. The kinematic data were registered in the free software CVMob, and the method of analysis of movement MED - Movement Element Decomposition was used.

For the preservation of the ethical aspects of the research, the study was duly approved by the Ethics Committee of the Centro Universitário Estácio da Bahia - Estácio FIB according to the resolution of the National Health Council - CNS 466/2012, under number CAAE 07025219.1. 0000.0041.

Results

The sociodemographic characteristics are shown in table 1, of the 03 children included in the study, 02 are male and 01 female, the average age of the participants was ± 6.66, with a minimum age of 06 years and a maximum of 07 years.

Table 1. Sociodemographic characteristics of the studied population, 2019

CHARACTERISTICS	C1	C2	C3
Age	6	7	7
Gender	F	M	M
Race	B	N	N
Student	YES	YES	YES

Source: sociodemographic characteristics of the children selected for the study. F- Female, M- male, B- white, N-black. Prepared by the authors, 2019.

As for gross motor function, according to the GMFCS, two children were classified as grade I, because they were able to walk independently and without restrictions. The other child was classified as grade II, despite being able to walk without the use of a device that helps in walking, has difficulties to perform more complex activities, frequently falling in the domestic and community environment. Regarding the topographic diagnosis of the children participating in the study, two had hemiparesis and tetraparesis. According to the Ashworth Scale, the highest degree of spasticity found in the assessed children was 02, present in the knee extensor and plantiflexor muscles, as shown in Table 2.

When evaluating the children's gait, all had internal hip rotation, flexor pattern on the knee during the initial and medium support phase, doing the extension only in the final support phase and inversion of the foot, only one child made the initial contact with the forefoot, the others performed with the heel, however, the dorsiflexion movement did not it was done completely. All patients had a slight / moderate decrease in static and dynamic balance, performing movements such as widening the step and anteriorizing the trunk to remain balanced.

Comparing the gait values of children with cerebral palsy with the normal values established by Dusing and Thorpe, it was observed that cadence, step length and speed tended to have lower values in children with cerebral palsy evaluated in this study. These differences are shown in Table 3.

Table 2. Classification of gross motor function according to the GMFCS scale, topography and the distribution of results for the degree of spasticity according to the Ashworth Scale

Features	Research subjects (n = 3)
Functionality (%)	
GMFCS level I	2 (66.66%)
II GMFCS level	1 (33.33%)
Topography (%)	
Hemiparesis	2 (66.67%)
Tetraparesis	1 (33.33%)
Degree of spasticity - n (%)	
Hip extensors (D / E)	
Grade 0	2 (D / E)
Grade 1+	1 (E)
Hip flexors (D / E)	
Grade 0	2 (D / E)
Grade 1+	1 (D / E)
Hip abductors (D / E)	
Grade 0	3 (D / E)
Hip adductors (D / E)	
Grade 0	2 (D / E)
Grade 2	1 (D)
Flexors knee (D / E)	
Grade 0	1 (D / E)
Grade 1	2 (1-E; 1-D / E)
Knee extender (D / E)	
Grade 0	1 (D / E)
Grade 1	1 (E)
Grade 2	1 (D / E)
Plantiflexors (D / E)	
Grade 0	1 (D / E)
Grade 1+	1 (D / E)
Grade 2	1 (E)
Dorsiflexors (D / E)	
Grade 0	2 (D / E)
Grade 1+	1 (D / E)

Source: Source: Level I : walks without restrictions, has limitations in more complex motor activities. Level 2: Walks without restrictions, presents difficulties in the environment and in the community. (D- right / E- left). Prepared by the authors, 2019.

Table 3. Distribution of space-time variables compared with the values that define the normality pattern

Gait pattern	Medium ± normal	C1	C2	C3
Speed (m / s)	1.25	0.64	0.58	0.96
Step length (m)	0.58	0.34	0 , 36	0.36
Cadence (w / min)	137.8	127	118	130

Source: normal mean (Dusing; Thorpe[9]) M / s- Meters per second; p / min-steps per minute; Comparison with normality values. Prepared by the authors, 2019.

Discussion

The present study presented the analysis of the linear gait parameters of three children with spastic cerebral palsy, comparing with the normal values for gait, presented in the literature. The values established by Dursing; Thorpe[9], show that the average speed, stride length and cadence have values of 1.25, 0.58 and 137.8 respectively, the values of these parameters were lower in the children evaluated. Children 1 (C1), 2 (C2) and 3 (C3), presented values of 0.64, 0.58, and 0.96 m / s for speed, 0.34, and 0.36 for step length and 127, 118 and 130 for cadence.

The speed values can vary from 0.62, 0.64 and 0.71 m / s in children with functionality I and II on the GMFCS scale, these values can be lower with the highest degree of impaired CP. The gait in children with cerebral palsy, when compared to the gait of children who do not have motor limitations and with typical development, presents different values in linear parameters, the values may be lower in children with CP, and motor changes may contribute to this decrease[10].

The main biomechanical changes found in the children in this study were: internal hip rotation, knee flexion and decreased ankle dorsiflexion. For Muller and Valentini[11] these changes cause changes in positioning and range of motion, implying a decrease in speed, stride length and cadence.

In cerebral palsy, the arthrocinemic movement of rolling, in the ankle is absent or decreased, due to changes in the position of the knee and ankle in the initial contact phase of the gait, due to spasticity, causing changes in speed, cadence, step length and distribution weight, generating greater energy expenditure[12]. When the initial contact is made by the front of the foot, there is a decrease in the recruitment of the fibers of the anterior tibialis, compromising the knee and hip extension, which remain semi-flexed during gait, implying their typical development[6].

This condition is defined due to the presence of the equine foot, caused by spasticity in the muscles of the sural triceps and weakness in the anterior tibialis, which reflects in the positioning of the limb, modifying the gait cycle[11]. Spasticity also prevents the musculature from growing in proportion to the growth of the bones, leading to contractures and a decrease in the size of the fibers, resulting in changes in the length of the steps and stride. The posture adopted in plantar ankle flexion and knee flexion is used as a compensation mechanism due to gait instability[13,11].

Fernandes et al.[3] states that children with cerebral palsy (CP) have relevant functional difficulties because they have a primitive musculoskeletal pattern, a decrease in proprioceptive and motor control, and spasticity, which in turn, stimulate a simultaneous neuromuscular activation of the antagonist muscle when there is voluntary stimulus changing the cycles and phases of the march.

The dynamic changes present in the gait are corrected by orthoses. The use of orthosis in children with CP is essential to provide stability, avoid contractures, deformities and muscle shortening, thus offering functional assistance and autonomy to the individual[13,1].

The results of a comparative study of children with CP, with and without the use of the orthosis performed by Bride et al.[12], found significant differences only in the increase in the length of the steps and passed with the use of the orthosis, whereas the results by Cury et al.[4] showed that the use of suropodalic orthoses provided beneficial changes in the qualitative parameters and in the gross motor performance of children with CP, mainly influencing the positioning of the foot in the initial contact phase, improving the weight distribution during the support phase, reducing equinism observed dynamic.

Thus, the ankle and foot or suropodalic orthosis has indications for having relevant benefits in the gait of children with CP, as it controls the excess of plantiflexion and assists in dorsiflexion, allowing changes in linear patterns and in decreasing energy expenditure. However, for its prescription, the professional must be aware of its objective and the type of orthosis to be indicated taking into account pathological aspects, and the changes found through analysis[12,1].

Saad et al.[14] reports that gait is a sequence of accelerated movements and difficult to understand, with great complexity in the evaluation, and its analysis is of fundamental importance in studies and treatment of pathologies that are readily involved with the locomotor system. For Sizinio et al.[15] normal gait is a prerequisite for analyzing and evaluating pathological marches, also stating that analysis has been seen as a good research tool, even in the face of adversities regarding the scarcity of laboratories, little investment in exams and in the training of professionals.

The results obtained in the present study identify a tendency to alter the gait values of children with cerebral palsy, which are directly related to the conditions of muscle tone and their motor limitations. Knowledge of the typical gait is a factor that determines the identification of changes in pathological gait, so gait analysis using the low-cost tool can have positive implications for evaluation and in determining the treatment plan, also helping in the correct prescription of devices as an orthosis to ensure the individual's well-being and functional independence.

Due to the limitation in the number of participants in this study, it was not possible to apply any statistical test, however, the spatio-temporal values found in the gait assessment of children with spastic CP are altered in view of the clinical and motor conditions present. Similar data found in other studies bet on these differences, reporting the benefit of using orthoses as an essential tool in correcting the positioning of the lower limb. The results of this study can assist in the process of evaluating and prescribing orthoses, as well as contributing to future research on this subject.

Conclusion

The results found for linear parameters showed that there was a decrease in speed, cadence and step length in the gait of children with cerebral palsy, when compared with normal values established in the literature. In this study, the values can be expected for this population due to the incorrect positioning of the limb, caused by changes in muscle tone caused by the presence of spasticity. Despite the small sample, there is evidence of a greater need to control gait variables in children with spastic cerebral palsy.

Author contributions

Magalhães PHS, Oliveira JGS participated in the collection and analysis of data and writing of the article. Sotero V guided and supervised the use of Cvmob and Med, evaluation of videos and organization of data. Bião MAS supervised the research, participated in the data analysis and in the writing of the article.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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