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ORIGINAL RESEARCH

Influence of different seats on postural alignment: hammock adapted for cerebral palsy

Influência dos diferentes assentos no alinhamento postural: rede adaptada para paralisia cerebral

Influencia de diferentes asientos en la alienación postural: hamacas adaptadas para personas con parálisis cerebral

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ABSTRACT | The hammock is an option to sit in the northern region of Brazil. However, its flexible structure can cause postural instability in individuals with cerebral palsy (CP), limiting their independence. Therefore, a hammock was created with a seat/back, seeking a seated positioning with adequate postural alignment. The objective was to verify the alignment of the trunk and lower limbs of individuals with CP in the conditions: adapted hammock, non-adapted hammock and bench, comparing them with control individuals without neurological disabilities. Six individuals with CP (CPG) and six individuals without neurological alterations (CG), aged between 8 and 14 years old, were evaluated in the seated posture under the conditions: adapted hammock, bench and hammock without seat/back support. By the kinematic analysis, angles of trunk, pelvis and lower limbs were evaluated in static posture for 5 seconds. Part of the Quebec B-Quest questionnaire was applied to the guardians. Results: lower limb, pelvis and trunk angles were similar in the three conditions. Quebec B-Quest: Greater satisfaction with product dimensions and less with comfort and safety. The adapted hammock can be considered an option to sit for short time, because it promoted postural control in individuals with CP.

Keywords | Cerebral Palsy; Self-Help Devices; Posture.

RESUMO | A rede de tecido é uma opção para o sentar na região norte do Brasil. No entanto, sua estrutura flexível pode causar instabilidade postural nos indivíduos com paralisia cerebral (PC), limitando sua independência. Assim, criou-se a rede adaptada, com inserção de sistema assento/encosto, buscando posicionamento sentado com alinhamento postural adequado. O objetivo deste estudo foi verificar o alinhamento de tronco e membros inferiores (MMII) de indivíduos com PC nas condições: rede adaptada, rede sem adaptação e banco, comparando-os com indivíduos-controle, sem alterações neurológicas. Seis indivíduos com PC (GPC) e seis típicos (GC), de 8 a 14 anos, foram avaliados na postura sentada nas condições: rede adaptada, banco e rede sem suporte de assento/encosto. Por meio da análise cinemática foram avaliados ângulos de tronco, pelve e membros inferiores na postura estática por 5 segundos. Houve aplicação de parte do questionário Quebec B-Quest com os responsáveis. Resultados: houve semelhança dos ângulos de MMII, pelve e tronco nas três condições. Quebec B-Quest: maior satisfação quanto às dimensões do produto e menor quanto ao conforto e à segurança. A rede adaptada pode ser considerada opção de sentar por curtos períodos de tempo, pois promoveu adequado alinhamento postural em indivíduos com PC.

Descritores | Paralisia Cerebral; Equipamentos de Autoajuda; Postura.

RESUMEN | Las hamacas hechas de tela son una opción de asiento en la región Norte de Brasil. Sin embargo, su estructura flexible puede generar inestabilidad postural

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en individuos con parálisis cerebral (PC), lo que limita su independencia. Se creó la hamaca adaptada, con la inserción de un sistema de asiento/respaldo, buscando una posición sentada con una alineación postural adecuada. El objetivo de este estudio fue verificar la alineación del tronco y las extremidades inferiores de individuos con PC en las siguientes condiciones: hamaca adaptada, hamaca no adaptada y banco, comparándolas con sujetos control, sin cambios neurológicos. Se evaluaron a seis individuos con PC (GPC) y seis típicos (GC), de 8 a 14 años de edad, en la postura sentada bajo las siguientes condiciones: hamaca adaptada, banco y hamaca sin asiento/respaldo. Por medio del análisis cinemático, se evaluaron los ángulos del tronco, la pelvis y las extremidades inferiores en la postura estática por 5 segundos. Una parte del cuestionario Quebec B-Quest se aplicó a los responsables. Hubo similitud de los ángulos de las extremidades inferiores, la pelvis y el tronco en las tres condiciones. Quebec B-Quest: mayor satisfacción en las dimensiones del producto, y menor en la comodidad y seguridad. La hamaca adaptada se puede considerar una opción de asiento durante períodos cortos de tiempo, ya que promovió una adecuada alineación postural en individuos con parálisis cerebral.

Palabras clave | Parálisis Cerebral; Dispositivos de Autoayuda; Postura.

INTRODUCTION

Cerebral palsy (CP) is defined as a group of permanent movement and posture disorders that restricts activities due to non-progressive disorders in the developing brain[1]. Individuals with CP have several functional limitations, according to the degree of severity and clinical diagnosis. Motor impairment is common, with poor regulation of movement and muscle strength production, in addition to perceptual deficits[2].

Despite the different sociocultural reality of the country, individuals share common clinical characteristics of CP, regardless of the region. Therefore, in addition to biometric adjustments for the user, devices must adapt to their cultural and motor needs to reduce the rate of abandonment[3].

In the North and Northeast regions of Brazil, the construction of an assistive technology device (AT) is a challenge due to the peculiar ways of sitting, such as in the hammock[4], which is an indigenous cultural heritage and has as main characteristics the ability to adapt to the hot and humid tropical climate, easy transportation, hygiene and installation, since it occupies a small space in the house[4].

The hammock, like the chair or bench, is an option to sit and perform activities. For individuals with CP, activities in the hammock are limited to rest. Flexible seats, such as the hammock, can cause postural instability and inability to use the upper limbs, negatively influencing the postural control of individuals with CP and even accentuating their motor dysfunction[5]. Stable and adapted surfaces facilitate the execution of the movement[6], contributing to the prevention of deficiencies secondary to CP[7]. Therefore, would it be possible to adapt the hammock, changing the seat structure and adding means for sitting postural stabilization? What are the effects of sitting in the hammock adapted for alignment of trunk and lower limbs in individuals with CP? Thus, our study sought to verify trunk and lower limb alignment under the following conditions: adapted hammock, non-adapted hammock and bench, comparing them with control individuals without neurological alterations. The hypothesis raised was that the adapted hammock would provide better alignment of trunk and lower limbs when compared with the bench and the hammock without adaptation.

METHODOLOGY

This is a quasi-experimental, comparative statistical clinical study approved by a *Research ethics committee* (1483/2015). We invited individuals with CP that attended rehabilitation centers in Santos (SP): Casa da Visão, Associação dos Portadores de Paralisia Cerebral (APPC) e da Associação Equoterapia de Santos. Individuals without neurological alterations were contacted among the university community, family, friends and acquaintances of the participants.

Of the 29 patients invited, seventeen were excluded: 13 did not meet the inclusion criteria; one did not complete the evaluation; and three were excluded due to loss of pairing, resulting in 12 participants, who were divided into two groups.

The inclusion criteria were: signing of the informed consent form by one of the guardians, diagnosis of bilateral spastic CP, with level II or III of the Gross Motor Function Classification System (GMFCS) and age group between 5 and 16 years. All participants were born in the state of São Paulo and lived in the municipality of Santos, in the same state.

The exclusion criteria were: individuals with dyskinetic or actic CP, spastic CP with unilateral involvement or that underwent surgery or neuromuscular chemical blockade less than six months before the study; and impairment of cognitive functions that hindered the evaluation.

The CP group (CPG) included six girls with bilateral spastic CP, one with level II and five with the LEVEL III of the GMFCS, average age of 10.5 years (SD=2.5), average weight of 27.75 kg (SD=12.01), and average height of 1.34 m (SD=0.17) in physiotherapeutic care. The control group (CG) consisted of six individuals without neurological alterations, four girls and two boys, average age of 10 years (SD=2.4), average weight of 29 kg (SD=9.38), average height of 1.31 m (SD=0.14). The groups were paired according to hip width (M=37.67 cm; SD=0). There was no difference in the comparison between age (t(10)=0.35; p=0.73), weight (t(10)=-0.20; p=0.84) and height (t(10)=0.27; p=0.79), demonstrating the homogeneity of the groups. There was no pairing regarding sex due to the difficulty in selecting the children.

For kinematic analysis, reflective markers were fixed at the anatomical points of the spine (7th cervical [C7], 4th and 12th thoracic [T4 and T12], 4th lumbar [L4] and 1st sacral [S1]) and bilaterally in: anterior superior iliac spines (ASIS) and posterior superior iliac spines (PSIS), major trochanter (MT) and lateral condyle of the femur (LC), lateral malleolus (LM) and head of the 5th metatarsal (HM). Four digital video cameras with a 60 Hz frequency were positioned laterally to the individual for the recording of the experimental protocol.

The hammock used had adjustments in the fabric structure so that the markers were visualized by the cameras. The adapted hammock also featured a removable seat/backrest system with rigid wood base coated with foam hardness 33 and non-slip fabric and a leg divider (Figure 1). The seats, identified by small, medium and large size, were made according to the average hip width of the individuals.

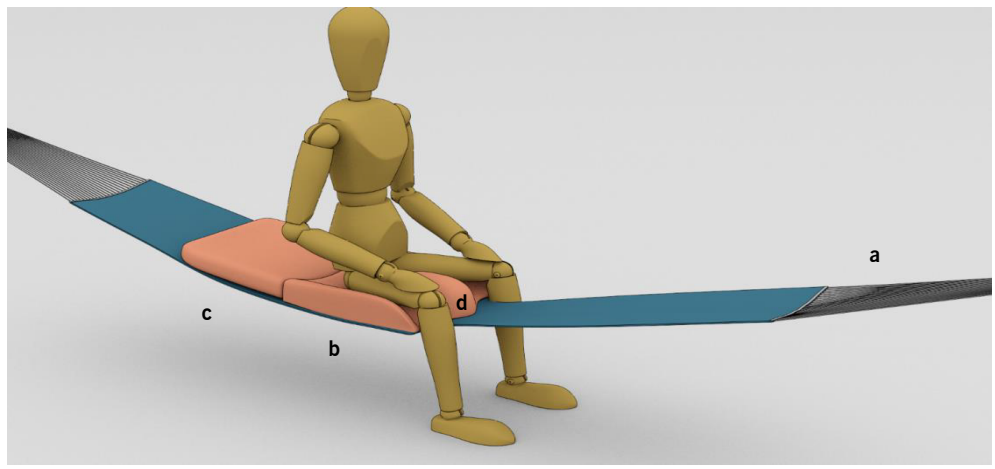

Figure 1. Adapted hammock, with seated positioning of the individual
a: handles; b: seat; c: backrest; d: leg divider.

The participants were evaluated sitting in three conditions: (1) hammock adapted with seat/back of size suitable for hip width; (2) hammock without seat/backrest adaptation; and (3) wooden bench (Figure 2). All seats accommodated the hip and thigh of the individual, leaving about 4 cm of the leg from the knee out of the seat. The height of the hammock in relation to the ground was adjusted to the height of the individual, and the sequence was randomized.

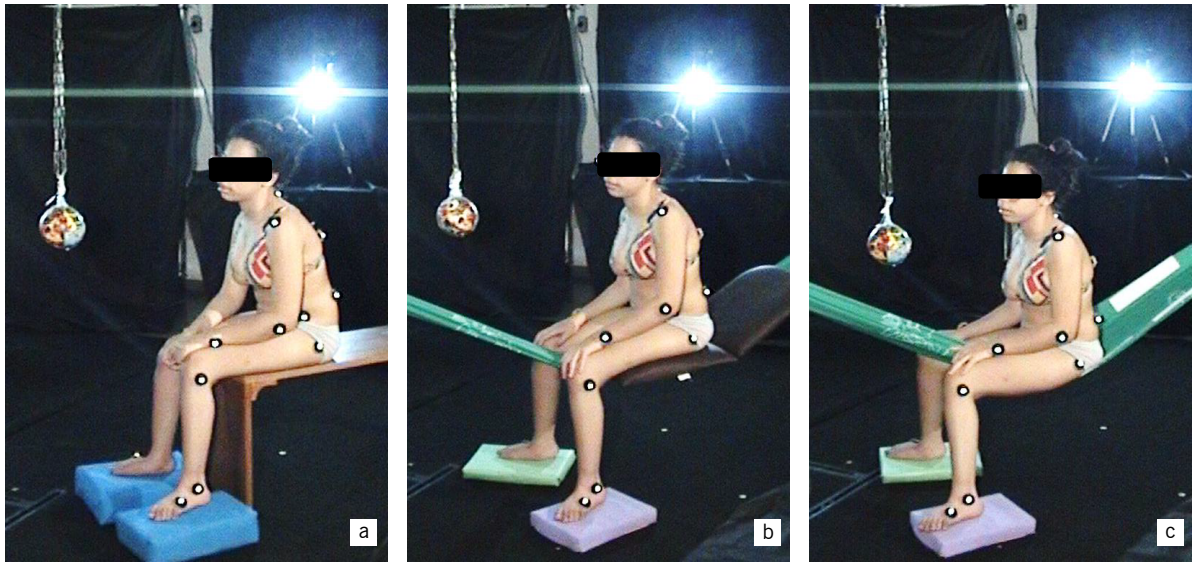

Figure 2. Sitting position in the three experimental conditions
a: bench; b: adapted hammock; c: non-adapted hammock.

In each condition, the individuals remained still, with hips flexed at 90º and abducted between 0º and 15º, upper limbs supported on the thighs, knees at 90º and feet supported on the floor. In some cases, it was necessary to use a base to adjust the height of the feet, 5 or 10 cm, coated with non-slip material. We needed 15 minutes to position the participant, adjust the base in relation to the height of the feet and activate the cameras before each condition. The individuals stared at an object placed at the height of their eyes and on the midline of the body for 5 seconds.

The evaluation lasted 1 h, and the length of stay in the laboratory was 1h30. At the end, the adapted hammock was evaluated by those responsible for the Satisfaction Questionnaire Quebec B-Quest (2.0), dimension Resource, in which each item can be scored as "very dissatisfied", "dissatisfied", "more or less satisfied", "satisfied" and "very satisfied".

The images were digitized using the Dvideow 5.0 System® to obtain the three-dimensional coordinates of the markers. We used the software MATLAB 7.9 for the filtering of the coordinates, through a filter butterworth of 4th order, with a cutoff frequency of 6 Hz and calculation of the variables. The variables analyzed were angles of thoracic kyphosis (angle between C7/T4/T12), lumbar lordosis (T12/L4/S1), pelvis (ASIS/PSIS/vertical axis), hip (ASIS/MT/LC); (LM/LC/MT) and ankle (LC/LM/HM). Moreover, pelvic positioning was classified as anteversion, neutral and retroversion by visual inspection of the images.

The assumptions of normality (Shapiro-Wilk) and homogeneity of variance (Levene) were tested. Multivariance (Manova) 2×3 (group × condition) analyses were used for the angular variables. When necessary, Anovas and Tukey's *post-hoc* tests were performed. A descriptive analysis of pelvic positioning was also performed. For the statistics, we used SPSS-19 software, adopting the significance level of 5%.

RESULTS

All participants were right-handed, except for one CPG participant, who was ambidextrous. In the CPG, one participant used a walker, three used a wheelchair and two did not use any locomotion device. One of the participants with GMFCS III needed a device but did not have it due to financial reasons, relying on family members to get around.

For the right lower limb, there were differences only for the group factor [Wilks' Lambda=0.69; F(3.27)=4.01; p=0.02]. The right ankle angle was lower for the CPG [F(1.29)=6.56; p=0.02] than for the CG. For the lumbar and thoracic spine, there was difference only for the group [Wilks' Lambda=0.74; F(2.28)=5.03; p=0.01]. The thoracic angle was lower for CPG [F(1.29)=7.18; p=0.01] than for CG. The other comparisons did not indicate significant differences (Table 1).

Table 1. Mean and standard deviation of angles for CPG and CG

Angle	Bench		Adapted hammock		Non-adapted hammock	
	CPG	CG	CPG	CG	CPG	CG
Hip R	90.13±12.47	85±9.38	78.68±13.89	86.48±15.5	63.11±10.05	81.46±19.51
Hip L	90.58±18.21	84.66±11.71	82.26±6.96	86.1±13.97	74.89±8.18	88.25±14.98
Knee R	101.43±9.35	98.48±4.35	98.45±11.01	99.73±11.83	87.42±17.32	87.65±6.38
Knee L	99.69±14.48	92.98±7.15	99.7±4.56	90.03±11.34	91.52±12.91	88.78±7.75
Ankle R	107.17±12.05	111.78±10.41	107.24±12.39	114.26±7.63	97.71±12.21	113.12±6.39
Ankle L	100.44±5.96	104.31±5.81	98.99±6.63	97.37±10.63	99.17±9.97	101.49±7.39
Pelvis	92.07±10.8	86.33±13.58	81.36±7.6	83.74±5.71	81.31±13.2	92.32±20.52
Thoracic	167.69±4.82	167.41±4.09	163.99±5.2	170.40±5.59	163.64±4.26	170.20±3.57
Lumbar	156.82±15.31	166.96±7.14	167.35±5.5	167.48±10.28	166.11±5.79	164.85±7.45

CPG: cerebral palsy group; CG: control group; R: right; L: left.

A retroverted pelvis was observed in the bench for CPG and CG; anteverted pelvis for CPG; and neutral pelvis for CG in both conditions in the hammock (Table 2).

Table 2. Pelvis positioning for CPG and CG

Pairing	Bench		Adapted hammock		Non-adapted hammock	
	CPG	CG	CPG	CG	CPG	CG
I	3	3	1	2	1	2
II	3	3	1	3	2	3
III	3	2	2	1	1	2
IV	1	1	1	3	1	3
V	3	3	1	1	1	2
VI	1	3	1	2	1	2
Median	3	3	1	2	1	2

CPG: cerebral palsy group; CG: control group; 1: anteverted pelvis; 2: neutral; 3: retroverted pelvis.

Regarding the Quebec B-Quest, most of those responsible were satisfied with the ease of handling the device, being equally satisfied when the resource met their needs. The fact that the adaptation is removable and the ease of assembling of the hammock were the most observed reasons. Most users were more or less satisfied with the dimensions (size, height, length and width of the adapted hammock) and comfort. Five mothers suggested a more anatomical seat in the thighs, as a contour. Most were dissatisfied with stability and safety, suggesting the addition of seat belts. All guardians reported that they would not leave their children alone in the hammock due to the risk of falls. Four CPG guardians had no hammock in the residence; two had, but for sporadic use. CG individuals had no hammock.

DISCUSSION

The similarity of the results of the angles in the three conditions may be related to the adjustment in the hammock. The hammock should be similar to the conventional one; however, it had to be adjusted to allow the visualization of markers. The variability of the results may have influenced the absence of difference between the angles of the pelvis, which can influence muscles and joints of the trunk and lower limbs[8]. Moreover, the standardization of the initial sitting position may have influenced the absence of differences.

Seat adaptation systems add stability to the sitting position, improving pelvis positioning and functionality, whereas more flexible structures generate greater instability. Thus, it can be inferred that the adapted hammock led to a good alignment of trunk, pelvis and lower limbs for both groups when compared with the bench, which is widely used in rehabilitation. The lack of difference between the seats indicates the feasibility in positioning individuals with CP on the hammock.

The use of the hammock in the Southeast is not as frequent as in the North and Northeast Brazil, where the hammock is part of the life of most inhabitants. Moreover, the hammock is widely used for lying down and, most of the time, sitting in the hammock is performed on the cross, and rarely "on horseback". These differences in reality and the condition of sitting among individuals that tested the adapted hammock may have influenced the level of product satisfaction by the guardians of individuals with CP.

Some have suggested to replace the leg divider by the contour. This type of seat is indicated for users that have extensor hypertonia, because it better positions the pelvis and decreases the constant slip in the seat[9,10]. Another suggestion was the insertion of seat belts in the hammock, which would lead to greater trunk stability with a lower support[11]. The adapted hammock needs improvement in the backrest that allows greater comfort in the change of positioning.

In the comparison between the groups, a lower angle of thoracic kyphosis was observed in the CPG, regardless of the seat, similar to Cunha, Polished and Bella[12].

This occurs because the compensation mechanism aligns the shoulder girdle with the pelvis due to the insufficient flexion of the hips by extensor hypertonia[13]. In CP, spinal deformities, such as increased thoracic kyphosis and decreased lumbar curvature, are related to postural control deficit, abnormal muscle activation and muscle weakness[14].

Despite the excessive posterior inclination of the pelvis in the sitting position to compensate for the shortened hamstrings[14] in individuals with CP being common, it did not occur in this study, probably due to the support on surfaces appropriate to the size of the hip and feet on a stable surface. We assumed that the choice of CP level contributed to this similarity, since individuals with bilateral spastic CP present better postural alignment sitting when compared with individuals with higher levels of motor disability[12].

The pelvis was influenced by the different types of seating for both groups, corroborating studies that related the inclination of the seat with the positioning of the pelvis[15]. In the database, four of the six individuals with CP presented pelvic retroversion, and when they switched to the hammock, there was a change to neutral or pelvic anteversion. The other two individuals may have not changed because they used pelvic fixation to maintain static balance when sitting[16].

Regarding individuals without neurological alterations (control group), in addition to variability, many individuals sat inadequately, regardless of the seat. Individuals without neurological alterations or fixed deformities in the spine may present sitting postural alterations due to inadequate daily habits[17].

There was a difference in the right ankle angle between the groups, with a lower angle in CPG, which may be associated with lateral asymmetry related to the dominance of the upper body segments[18]. In addition to lateral asymmetry, it is likely that to remain in position and, at the same time, ensure stability, the individuals of the CPG tended to postural compensation, evidencing trunk and pelvis asymmetry[11] and contributing to the constant weight pressure only to the right side, since most patients were right-handed. It is likely that increased ankle dorsiflexion was the balance strategy used to fixate on sitting posture. However, as the lateral trunk asymmetry was not evaluated, we suggest caution regarding these statements.

The limitations of this study were: the small anterior tilt of the adapted hammock, associated with the mandatory knee positioning at 90º in static tasks; the reduced sample size due to the difficult access to the population with CP; and the lack of pairing the participants according to the gender.

We concluded that the adapted hammock was similar to the bench and non-adapted hammock in the permanence of the sitting static posture for short periods. Most parents were satisfied with the dimensions of the adapted hammock and its ease usage. However, they pointed out that the product needs adjustments related to comfort and safety. Therefore, the adapted hammock can be considered another option of sitting for individuals with CP, because it resembled the results of the database, widely used in the daily life of individuals with CP.

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