Growth and anthropometry in hemiplegic cerebral palsy patients

Crescimento e antropometria em pacientes com paralisia cerebral hemiplégica

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ABSTRACT

Objective: To analyze the linear growth, the head circumference and the anthropometric differences between involved and non-involved sides of 24 children with hemiplegic cerebral palsy, comparing them to standard values for age.

Methods: This cross-sectional study enrolled 24 consecutive children with cerebral palsy clinically classified as spastic hemiplegia. The anthropometric measures included: weight, lenght, head circumference, total upper limb length, hand length, palm width, total lower limb length, foot length, and limb circumference of upper-arm, thigh and calf. The anthropometric differences between both sides were calculated in centimeters and a comparison of the involved and non-involved sides was made. Two different reference values were used to compare the measures of hand and foot length: growth charts and the software ABase® (a PalmOS-based software). The Spearman's correlation coefficient was estimated for the association between quantitative variables and the Wilcoxon non-parametric test was used for age comparisons between involved and noninvolved sides.

Results: The mean values of weight, length and head circumference were within the normal range for age and 21% of the children presented microcephaly. Discrepancy was noted between both sides in all cases, being the largest discrepancy in hand length and width. There was a positive correlation between the discrepancy observed in superior and inferior affected limbs (r=0.48), and discrepancy increases with age (r=0.44).

Conclusion: Growth impairment in children with hemiplegic cerebral palsy was observed on the affected limbs and in smaller proportion in head circumference.

Key-words: anthropometry; cerebral palsy; hemiplegia; growth; child.

RESUMO

Objetivo: Analisar o crescimento linear, o perímetro cefálico e as diferenças antropométricas entre o lado envolvido e o não-envolvido de 24 crianças com paralisia cerebral (PC) hemiplégica, comparados à média para a idade.

Métodos: Estudo transversal com amostragem consecutiva de crianças com PC, classificadas clinicamente como hemiplegia espástica. As medidas antropométricas incluíram: peso, estatura, perímetro cefálico, comprimento total de membro superior, comprimento da mão, largura da palma da mão, comprimento total do membro inferior, comprimento do pé e a circunferência dos membros (braço, coxa e panturrilha). As diferenças antropométricas entre os dimídios foram calculadas em centímetros e como porcentagem de encurtamento, comparando o lado envolvido com o não-envolvido. Dois referenciais populacionais, tabelas de crescimento e o software ABase®, desenvolvido para sistema PalmOS, foram comparados na classificação das medidas do comprimento da mão e do pé. A análise estatística utilizou o coeficiente de correlação de Spearman para avaliar a associação entre variáveis quantitativas e o teste não-paramétrico de Wilcoxon para comparar as medidas do lado envolvido e não-envolvido.

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Resultados: As médias de peso, estatura e perímetro cefálico se mostraram dentro dos limites normais para a idade e 21% dos pacientes apresentaram microcefalia. A discrepância entre os dimídios foi evidente em todos os casos, sendo maior na largura e comprimento da mão. Houve correlação da discrepância observada entre os membros superiores e inferiores no lado envolvido (r=0,48) e a discrepância aumenta com a idade (r=0,44).

Conclusões: O maior comprometimento no crescimento das crianças com paralisia cerebral estudadas ocorreu nos membros envolvidos pela hemiplegia e, em menor proporção, no perímetro cefálico.

Palavras-chave: antropometria; paralisia cerebral; hemiplegia; crescimento; criança.

Introduction

Cerebral palsy (CP), also called chronic nonprogressive childhood encephalopathy, is caused by a brain lesion occurring during structural and functional maturation of the brain, in the pre-, peri- or postnatal period[1]. Children with CP are usually affected by growth impairment, having lower weight and height than healthy children at the same age[2]. Rotta[3] emphasized that these children, in addition to showing lower height and weight, are also less resistant against infections, highlighting the importance of having a normal brain so that normal physical development can be achieved.

Growth retardation in children with chronic diseases, such as CP, has a multifactorial etiology[4], and it can even be associated with non-nutritional factors resulting from brain malformation or lesions responsible for the child's disability[2,5]. The moment when the lesion leading to CP occurred[6], the type of movement disorder[2], the severity of CP, mainly regarding self-feeding and walking capacity[7], and the level of physical activity limitation[4] have been described as factors that can have an influence on growth disorders.

Growth retardation is more important in spastic quadriplegic CP[4,8], but it has been also reported in children with diplegia and hemiplegia[2], even when there is not malnutrition. In children with CP, approximately 35 to 40% have spastic hemiplegia, with one side of their body being more severely affected than the other[9,10]. Previous studies have demonstrated growth disorders[10,11], delay of muscle development[5,11] and bone maturation[12] in the affected limbs of children with hemiplegia.

Due to the basic relations between the growth of different parts of the body, disorders of the normal growth may be detected by anthropometry, which is the study of the comparative measures of the human body[6]. This is a simple, non-invasive, and inexpensive technique. Therefore, anthropometry is the tool of choice to assess dimorphisms in children; nevertheless, it has been rarely used in the clinical practice[13]. The following are the most important probable reasons for its restricted use: limited access of professionals to appropriate reference values, long time spent taking the measures, and long time spent entering data in the growth charts. Currently, specific computer programs, such as ABase® developed for the PalmOS-based system of palmtops, provide anthropometric data that enable the fast comparison of measures, considering the patient's age and sex[13].

Within this context, the objective of the present study is to analyze linear growth, head circumference, and anthropometric differences between both sides of the body of children with hemiplegic CP, as well as the relation between head circumference and cognitive function and between anthropometric differences and motor function.

Method

This is a descriptive cross-sectional study. Our consecutive sample comprised children with spastic hemiplegic CP who were being followed up at the pediatric spasticity outpatient clinic of the Center of Neuropediatrics of Hospital de Clínicas of Universidade Federal do Paraná (UFPR), Curitiba, Brazil. The patients' age ranged from 3 to 5 years old and they were seen at the outpatient clinic from June 2005 to April 2006. The patients had independent mobility and their motor impairment was classified as level I and II according to the Gross Motor Function Classification System (GMFCS)[14]. At the outpatient clinic, which provides care to children with CP referred by different health care units, assessments are carried out by a multidisciplinary team. The last author of the present study is responsible for neurological assessment and functional classification. Counseling is provided by specific health professionals (physical therapist, occupational therapist, psychologist, and nurse) to each family. None of the children included in the present study had a history of concomitant genetic, metabolic, neurodegenerative disease or any other disorder that could affect their growth. Preterm children or those with low birth weight were not excluded. This study was initiated after the project was approved by the Research

Ethics Committee of Hospital de Clínicas of Ufpr. The children's guardians agreed with their participation in the study and signed a written consent form.

Measurements were taken in the morning always by the same professional, according to standardized rules[15], and they included total upper limb length, hand length, hand width, total lower limb length, foot length, and limb circumference (upper-arm, thigh, and calf). The discrepancy found between both sides of the body was calculated in centimeters and percentage by comparing the affected and unaffected sides according to the following formula adapted from the study by Demir *et al*[16]: "Measure of unaffected side - measure of affected side x 100 / Measure of unaffected side"

Values of hand length were compared with data by Feingold and Bossert[17], and values of foot length were compared with data by Blais *et al*[18] for boys and girls used by Hall *et al*[15]. These measures were also compared with the values by Freeman *et al* using the computer program ABase®[13,19], which offers reference values for 18 anthropometric measures frequently used for dimorphisms, and the results are expressed in text format and digital growth charts. In the present study, the result was expressed in text format. The computer program is available free of charge at www.medgen.unizh.ch/abase/.

Weight, height and head circumference were measured in the morning during medical visits at the outpatient clinic. All children were measured in supine position using a wooden anthropometer. Weight was measured using a mechanical scale Fillizola, since all children were classified as level I and II of the GMFCS, being able to stand on the scale. Z scores were calculated using the computer program ABase®, which has the European population as reference[19]. All measures, expressed in percentile or Z score, were considered abnormal when > 2 standard deviations (SD) above or below the mean or not between the fifth or 95th percentiles[19].

Motor function was assessed using the Gross Motor Function Measure (GMFM)[20], developed and validated for children with CP[21], being widely accepted even in Brazil[22]. This scale was administered by the same trained professional. It comprises 88 items that assess the function related to five dimensions of motor progress: (A) lying and rolling, (b) sitting, (C) crawling and kneeling, (D) standing, (E) walking, running, and jumping.

The WPPSI-R (Wechsler Preschool and Primary Scale of Intelligence-Revised) test[23] was used to assess the cognitive function. This clinical instrument is a complete revision of the 1989 WPPSI (Wechsler Preschool and Primary Scale of Intelligence) designed for individual administration assessing different aspects of the intelligent of children from 3 to 7 years. It includes 12 subtests divided into two areas: Verbal and Performance.

The results of the present study were expressed as mean and SD or as frequencies and percentages. With the purpose of assessing the association between quantitative variables, we estimated the Spearman's correlation coefficient. We compared the results from each side (affected and unaffected) with quantitative variables using the Wilcoxon nonparametric test, and the level of significance was set at $p<0.05$. Data were entered in an Excel spreadsheet and analyzed using the computer program Statistica v.6®.

Results

Twenty-four children with hemiplegic CP participated in this study. Nineteen (79%) of them were males and their mean age was 49.3±5.2 months. With regard to laterality, 11 (45.8%) of the patients had the right side affected. Five (21%) were preterm infants and 19 (79%) were born at term. The height of three male patients was below -2 SD. Of them, two also presented with low weight and microcephaly; one of them was premature and both were small for gestational age. Cognitive status was considered normal (≥80) in 13 children (57%), and retardation (<80) was detected in 10 (43%) children. There was not a statistically significant correlation between cognitive status and head circumference ($r=0.04$; $p=0.85$). The assessment of gross motor function detected a mean score of 93±12%.

Mean weight was 15.5±1.5kg, while mean height was 99.7±4.6cm. Mean head circumference was 48.8±2.3cm and, in 21 % of the children, it was lower than -2 SD. Information regarding these data and their respective z scores and percentiles for each child are described in Table 1.

All children who participated in the present study had lower values in at least three of the measures related to the affected side. All means for length, width and circumference measures were significantly lower in the affected side when compared to the means of the unaffected side ($p<0.001$), and the larger discrepancy was found regarding hand length and palm width (Table 2). The correlation analysis showed that the higher the difference in the total length of the upper limb affected, the higher the difference in the hand length and palm width ($r=0.52$). The higher the difference in the palm width,

Table 1 – Gender, anthropometric data and intelligence quotient (IQ) in the population studied

	Gender	Weight		Height		Head circumference		IQ
		kg	Z score	cm	Z score	cm	Percentile[a]	
1	M	18.0	0.95	99	-0.56	51.5	-2 SD - M[d]	45
2	M	16.4	-0.39	102	-0.75	47.5[b]	-3.7 SD	52
3	M	17.5	0.39	104	0.08	50.2	-2 SD - M[d]	81
4	M	17.0	0.07	102	-0.50	49.0	-2 SD - M[d]	80
5*	F	16.0	-0.34	103	-0.19	42.0	-3.6 SD	56
6	M	15.5	-1.22	102	-1.21	49.5	-2.4 SD	74
7	M	14.5	-0.48	100	0.24	49.0	-2 SD - M[d]	77
8*	M	16.5	-0.08	102	-0.38	49.0	-2 SD - M[d]	99
9	M	14.8	-1.30	102	-0.75	45.6[b]	-2 SD - M[d]	67
10	F	17.9	1.32	102	1.03	48.0	-2 SD - M[d]	88
11*	F	13.7	-1.76	94	-2.39	46.5[b]	-4.4 SD	101
12*	M	16.0	0.45	105	1.60	51.0	-2 SD - M[d]	44
13	M	16.2	0.74	98	0.20	48.4	-2.6 SD	126
14	M	15.0	-1.08	100	0.17	47.5	-3.6 SD	43
15	M	14.5	-1.03	100	-0.59	49.0	-2 SD - M[d]	98
16	F	13.5	-0.54	96	0.01	49.2	-2 SD - M[d]	61
17	M	15.5	-0.70	88	-3.61	52.8	-2 SD - M[d]	72
18	M	13.6	-2.12	98	-1.54	48.2	-3.0 SD	94
19	M	16.2	0.11	104	0.63	53.0	M - +2 SD[e]	76
20	M	13.0	-2.58	91	-3.22	47.7[b]	-3.7 SD	50
21	M	17.7	-0.18	106	-0.45	49.5	-2.4 SD	94
22*	M	13.0	-2.58	91	-3.22	47.7[b]	-3.7 SD	[c]
23	F	16.0	-0.05	98	-0.70	48.4	-2.9 SD	83
24	M	15.0	-1.08	104	-0.17	51.0	-2 SD - M[d]	141

* Preterm children: 33, 34, 26, 32 and 27 weeks; [a]Data from the computer program ABase®; [b]data corresponding to -2 standard deviations (SD) in the growth chart; [c] unavailable data; [d] -2 SD – M: value between -2 SD and mean; [e]M - +2 SD: value between the mean and +2 SD.

Table 2 – Relation between the measures of the affected and unaffected sides

	Mean of the difference between the two sides (cm)	Percentage of lower measures of AS (mean)	Proportion of AS compared to UAS (%)
Total UL length	1.22±0.94	2.65	96.66
Hand length	0.88±0.54	6.10	92.82
Palm width	0.36±0.34	5.99	92.50
Total LL length	0.65±0.65	1.50	97.82
Foot length	0.73±0.56	4.41	96.06
Upper-arm circumference	1.12±0.57	5.75	94.44
Thigh circumference	0.88±0.63	2.68	96.87
Calf circumference	0.88±0.53	4.25	96.55

UL: upper limb; LL: lower limb; AS: affected side; UAS: unaffected side.

the higher the difference in the foot (r=0.48). The older the patient, the higher the percentage of lower upper-arm circumference, whereas the older the patient, the larger the discrepancy (r=0.44).

When we compared the data from the growth chart and ABase®, we found divergent results in 32% of the data related to hand length and in 18% in terms of foot length (Tables 3 and 4). These divergent data show that the computer program ABase® assigned lower values, except for one case. In addition, in three cases related to hand length and in two cases related to foot length, there were divergent results regarding the classification of normality.

Table 3 – Comparison of the values of hand length considering data from the growth chart and from ABase® in all the 24 children

	Age	Unaffected side (cm)	Growth chart[a] (SD)	ABase®[b] (SD)	Affected side (cm)	Growth chart[a] (SD)	ABase®[b] (SD)
1	3y 11m	12.5	75-97	61	11.5	25-50	13*
2	4y 3m	12.0	25-50	48	11.5	3-25	7
3	4y 2m	11.7	25-50	8*	10.5	<3	-3
4	4y 2m	12.5	50-75	50	11.5	3-25	8
5	4y 5m	12.5	50-75	43*	11.0	3-25	6
6	4y 10m	12.5	50-75	31*	12.0	25-50	31
7	3y 9m	10.9	3-25	-2*	10.0	<3	-2
8	4 years	11.5	25-50	11*	11.0	3-25	11
9	4y 5m	12.2	25-50	43	11.5	3-25	6
10	3y 8m	12.0	50-75	69	10.5	3-25	1*
11	4y 1m	11.0	3-25	9	10.0	<3	-3
12	3y 5m	11.2	25-50	25	11.0	25-50	25
13	3y 3m	12.0	75-97	80	12.0	50-75	80*
14	4y 3m	13.0	75-97	90	11.0	3-25	7
15	3y 11m	11.5	25-50	13*	10.5	3-25	-2*
16	3y 3m	11.0	25-50	29	10.5	3-25	2*
17	4y 3m	11.0	3-25	7	9.3	<3	-4
18	4y 5m	10.5	<3	-3	10.0	<3	-3
19	3y 10m	12.0	50-75	64	10.0	<3	-2
20	4y 5m	10.5	<3	-7	10.2	<3	-7
21	4y 10m	12.8	50-75	31*	12.0	25-50	31
22	4y 6m	11.5	3-25	5	10.8	3-25	-3*
23	4 years	11.5	25-50	11*	11.0	3-25	11
24	4y 7m	12.5	25-50	45	12.0	25-50	45

*Divergent data between both reference methods; [a] comparison with data by Feingold[17]; [b]data from the computer program ABase® in text format, based on data by Freeman *et al*[19].

Discussion

Growth is an essential aspect of child development, being a marker of health and well-being[24]. Abnormal growth between the two sides of the body in children with hemiplegic CP is used as a model for the study of the influence of non-nutritional factors on growth. The fact that each child is her/his own control makes it possible to rule out factors such as malnutrition, endocrinological aspects, gender, race, parents' mean height, and puberty stage[5].

Since there is no significant difference between the both sides of the normal child's body, which was previously demonstrated by Demir *et al*[16], in the present study, we used the unaffected side in comparison with the affected side in children with hemiplegic CP, as described by Stevensen *et al*[5] and Van Heest *et al*[25], who also included both sexes in the same sample. Disorders in the linear or specific growth of limbs of children with CP and head circumference can be measured and compared with reference values for the general population.

Although anthropometry is the technique of choice to assess dimorphisms in children, in the clinical practice, it has been seldom used. The fact of being time-consuming and the occasional lack of appropriate charts for the several body measures may explain its rare use. The computer program ABase®[13] was designed with the purpose of minimizing this problem. In the present study, we compared the findings resulting from the use of both methods, growth charts and ABase®, and some differences were detected. Growth charts provide ranges of values for the classification of the patient's measures, while ABase®, used in the text format, provides a specific value. We found differences regarding the results provided by both reference methods, since approximately one fourth of results showed divergent data between the information provided by ABase® and the growth curve. The fact that ABase® uses the European population as reference[19] might be one of the reasons for such divergent results. In the present study, when the symmetry and the proportions of each individual were analyzed, the growth charts provided information that made it easier to compare

Table 4 – Comparison of the values of foot length considering data from the growth chart and from ABase® in all the 24 children

	Age	Unaffected side (cm)	Growth chart[a] (SD)	ABase®[b] (SD)	Affected side (cm)	Growth chart[a] (SD)	ABase®[b] (SD)
1	3y 11m	16.5	50-75	50	15.5	25-50	13*
2	4y 3m	17.5	75-97	73*	16.5	25-50	31
3	4y 2m	16.0	25-50	34	16.0	25-50	34
4	4y 2m	16.0	25-50	34	16.0	25-50	34
5	4y 5m	16.5	25-50	26	16.5	25-50	26
6	4y 10m	17.5	50-75	51	16.0	3-25	15
7	3y 9m	16.0	50-75	58	15.0	3-25	19
8	4 years	16.0	25-50	41	16.0	25-50	41
9	4y 5m	17.7	50-75	67	16.0	25-50	26
10	3y 8m	16.8	50-75	62	15.7	25-50	22*
11	4y 1m	15.8	25-50	7*	14.7	3-25	-2*
12	3y 5m	16.0	50-75	73	15.0	25-50	33
13	3y 3m	16.0	75-97	79	16.0	75-97	79
14	4y 3m	17.0	50-75	73	15.5	3-25	5
15	3y 11m	15.5	3-25	13	14.0	<3	1*
16	3y 3m	15.5	25-50	41	15.0	25-50	41
17	4y 3m	15.0	3-25	5	14.0	<3	-3
18	4y 5m	15.5	3-25	4	15.0	3-25	4
19	3y 10m	16.7	50-75	54	16.3	25-50	54
20	4y 5m	15.5	3-25	4	14.5	<3	-3
21	4y 10m	18.0	75-97	85	17.5	50-75	51
22	4y 6m	15.3	3-25	3	14.4	<3	-3
23	4 years	17.0	75-97	81	16.5	50-75	41
24	4y 7m	16.5	25-50	21*	16.5	25-50	21*

*Divergent data between the two reference methods. [a]Comparison with data by Blais *et al*[18]. [b]Data from the computer program ABase® - based on data by Freeman *et al*[19], in text format.

the measures of both sides of the body. On the other hand, depending on the objective of the anthropometric assessment, tools such as the computer program ABase® make assessment simpler, mainly in terms of time consumption. The fact that the results obtained from these two reference methods are not interchangeable suggests that the choice of the reference method should be previously made and used for all assessments.

Holt[26] analyzed the growth of 50 children with hemiplegia and found that they tended to have lower weight and height in comparison with the population mean, while Maekawa *et al*, cited by Uvebrant[11], did not find this trend. In our sample, the mean values were within the normal range, although three patients had weight and height deficit, which was not related to nutritional factors, and these cases are currently being investigated. Uvebrant[11] analyzed 169 children with hemiplegia and found that weight and height means were not significantly different from the normal values either. The data of the present study are in agreement with the absence of difference in the linear growth of these children in comparison with the normal population.

It is possible that one of the factors that stimulates linear growth in patients with hemiplegia is the possibility of a motor performance close to the normal. The mean score on the GMFM (93%) in the present sample suggested motor ability very similar to normal performance, considering that the expected result in this scale is that 5-year-old normal children are able to complete 100% of the items. Studies have demonstrated the benefit of physical activity in terms of growth and development stimulation[27], while other studies have considered that the severity of the growth disorder in CP could also be related to physical activity limitation[4]. The study by Ibrahim and Hawamdeh[8] associated a more adequate growth in CP with better motor function and demonstrated lower impairment in the hemiplegic children compared to the diplegic and quadriplegic children. The fact that the children included in our study had a motor function similar to normal suggests that they are also highly prone to have more adequate social participation and health indicators than children with CP who have more severe growth disorders, as demonstrated by Stevensen *et al*[24].

Head circumference, which is one of the most important measures during childhood, reflects the intracranial volume of the brain under development. The presence of discrepancy in its proportion may suggest pathological processes[15]. In the present study, 21% of the patients had microcephaly. Stewart (1948), cited by Uvebrant[11], found small head circumference in almost all cases of hemiplegia investigated in his study, which was not corroborated by our findings and by Uvebrant's results[11], who found that 15% of the subjects had head circumference measures lower than -2 SD. Recently, Ibrahim and Hawamdeh[8] found a significant decrease in the head circumference of hemiplegic girls.

Few studies have attempted to associate microcephaly and cognitive function. The WIPPSI-R test[23] used in the present study to assess cognitive function is approved by the Federal Council of Psychology to be used with this age group. This test has been used for some years at the outpatient clinic for newborns at risk of Hospital de Clínicas of UFPR, detecting an intelligence quotient < 80 in 5-year-old children who failed the Denver II test twice or more at 2 years old, with sensitivity and specificity of 70%[28]. In the present study, there was not correlation between cognitive function and head circumference. Uvebrant[11], on the other hand, found that children with head circumference < -2 SD had an increase of 55% in the incidence of mental retardation, whereas those with head circumference > -2 SD had an increase of only 21%.

Compared to the normal height and weight, the asymmetry of growth between the both sides of the body of children with hemiplegia was evident, and the affected side was smaller and shorter in terms of length, width and circumference, which was also found by Stevensen *et al*[5]. Uvebrant[11] found hypertrophy in 96% of the cases and frequent growth disorder in the affected limbs, with mean discrepancy of 15mm in the upper limb and 6mm in the lower limb. In the present study, these means were 12.2mm and 6.5mm, respectively. Holt[26] found that 20% of the hemiparetic children had a percentage of >2.5% of shorter affected legs, which represented 20mm; 62% had <20mm of shorter measures, and 18% did not have shorter measures. In the study by Uvebrant[11], these findings were 13%, 75%, and 12%, respectively, and, in our sample, the values were 8%, 50%, and 42%. Comparing the data of the present study with those provided by the above mentioned studies, we found that in the present sample the shortness of the arm was also more significant than the shortness of the leg.

The higher disproportion between both sides of the body in hemiplegia would be related to the hand and the foot[10]; however, in the present study, the higher disproportion was observed in terms of palm length and width, followed by upper-arm circumference, which is in agreement with Tizard *et al*[29].

There is controversy on the relation between discrepancy in the growth of the affected side and age[5,16,24]. In the present study, the mean age was younger and more homogeneous if compared to the mean age of the subjects included in the studies that investigated the relation between growth discrepancy in the affected side and age[5,16,24]; even though, we found that the older the age, the higher the percentage of decrease in the circumference of the affected upper-arm. This reinforces the term used by Tizard *et al*[29], "undergrowth," since the process of lower growth is related to the difficulty to grow instead of being related to a retrogression. Even if later there is worsening due to lack of activity, the lower measure of the limbs occurs early during the growth process. In the normal development, growth of different parts of the body occurs according to a predicted and proportional process[15]. The relationship found between the measures of the upper and lower limb of the affected side suggests that there is a natural trend to the proportional growth of this side, even when there is evident asymmetry regarding the unaffected side.

The cause of discrepancy between both sides in hemiplegic CP has not been fully clarified yet. Among the hypothesis discussed, these are the most important ones: lower blood flow in the limbs, lesions in the postcentral cortex and consequent lack of use and, probably, association of these factors[11]. Stevensen *et al*[30], while investigating the mechanisms of abnormal growth in CP, considered if non-nutritional interventions, such as weight bearing and physical therapy, could have a positive impact on the growth of these children, which has not been clarified yet. Demir *et al*[16] found significant differences in the measures of the upper limb between both sides of children with hemiplegic CP; however, the degree of lower measures is not related to spasticity. The influence of physical therapy could not be controlled in the present study, since our patients were treated with physical therapy at several different health facilities. There is need of further studies with the purpose of checking the influence of disorders (such as degree of spasticity, muscle weakness and sensitivity alterations) in the lower growth of the affected side and its relation with the functional use in children with hemiplegic CP, as well as investigation of the factors that may stimulate a better growth of the affected side and the influence on the physical therapy treatment.

The inclusion of five preterm children may be called into question; however, there are not studies comparing these data in preterm children, either adequate or small for gestational age. Further studies involving a larger number of preterm patients are necessary to corroborate these findings.

In conclusion, we can assume that the most frequent growth disorders in children with hemiplegic CP are related to the discrepancy between both sides of the body and head circumference, without any alterations in the linear growth. The discrepancy between both sides of the body was evident, being more significant in terms of palm width and length, and 21% of the patients had microcephaly, which was not related to the cognitive function. The reference values of normality used in the present study, growth charts and ABase®, were not interchangeable; therefore, pediatricians should previously select the instrument and keep using it for all assessments.

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