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Evaluation of food intake, weight and body composition in children with cerebral palsy

Avaliação da ingestão alimentar, peso e composição corporal em crianças com paralisia cerebral

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ABSTRACT

Aim: We investigated food intake, weight and body composition evaluation in children with cerebral palsy.

Method: A case-series study was conducted involving 53 children with mild to moderate motor impairment. Food intake was estimated and bioimpedance was used to determine body composition, with the calculation of the free fat mass index and fat mass index (FMI). The anthropometric profile was determined using z-scores of the following indices: height-for-age (zH/A), weight-for-age (zW/A) and body mass index-for-age (zBMI/A).

Results: Height deficit was found in 7.5% of the children. Excess weight was found in 20.8% (zW/A) and 30.2% (zBMI/A). The prevalence of underweight was 7.5% (zW/A) and 5.7% (zBMI/A). Excess fat mass was found in 77.4%. No associations were found between excess fat mass or fat-free mass and excess weight or calorie intake. Height was positively correlated with age, mobility and zH/A. FMI was positively correlated with age and height. Lipid intake was positively correlated with age, height and FMI.

*Conclusion***:** The nutritional status and food intake of the children analyzed in the study was similar to that of children without neurological disease, possibly due to the lower degree of motor impairment.

Keywords: Cerebral Palsy, Nutritional Status, Food Intake, Body Composition, Anthropometry.

RESUMO

Objetivo: Investigamos a ingestão alimentar, o peso e a avaliação da composição corporal em crianças com paralisia cerebral.

Método: Foi realizado um estudo de série de casos envolvendo 53 crianças com deficiência motora leve a moderada. A ingestão alimentar foi estimada e a bioimpedância utilizada para determinar a composição corporal, com o cálculo do índice de massa gorda livre e índice de massa gorda (IMG). O perfil antropométrico foi determinado por meio de escores z dos seguintes índices: altura para idade (zH / A), peso para idade (zW / A) e índice de massa corporal para idade (zBMI / A).

Resultados: O déficit de altura foi encontrado em 7,5% das crianças. Excesso de peso foi encontrado em 20,8% (zW / A) e 30,2% (zBMI / A). A prevalência de baixo peso foi de 7,5% (zW / A) e 5,7% (zBMI / A). Excesso de massa gorda foi encontrado em 77,4%. Não foram encontradas associações entre o excesso de massa gorda ou massa livre de gordura e o excesso de peso ou ingestão de calorias. A estatura correlacionou-se positivamente com a idade, mobilidade e zH / A. O IMF foi positivamente correlacionado com a idade e a altura. A ingestão de lipídios correlacionou-se positivamente com idade, altura e IMG.

Conclusão: O estado nutricional e o consumo alimentar das crianças analisadas no estudo foram semelhantes aos de crianças sem doenças neurológicas, possivelmente pelo menor grau de comprometimento motor.

Palavras-chave: Cerebral Palsy, Estado nutricional, Ingestão de alimentos, Composição do corpo, Antropometria.

1 INTRODUCTION

Growth variables and body composition are significantly altered in patients with cerebral palsy (CP). Alterations in body composition vary in accordance with the degree of motor impairment.[1] With regard to food intake, individuals with CP have similar caloric and macronutrient intake as children with typical development.[2] It is therefore necessary to evaluate body composition and food

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intake for the determination of the nutritional status of such individuals and identify situations of risk in order to plan health promotion and disease prevention actions.

The aim of the present study was to evaluate food intake, weight and body composition in children with mild to moderate CP.

2 MATERIALS AND METHODS

2.1 STUDY AND PARTICIPANTS

A case-series study was conducted between February and August 2016 at three centers for the follow up of children with CP. Children with severe motor impairment, congenital malformation unrelated to CP, those with chromosome, heart or respiratory diseases, those with hearing or seeing impairment, and those submitted to surgery of the musculoskeletal system or botulinum toxic injection in the previous six months were excluded from the study.

The clinical characterization included the type of CP (classified as spastic or other type) and degree of motor impairment based on the Gross Motor Function Classification System (GMFCS).[3]

2.2 NUTRITIONAL ASSESSMENT

The anthropometric evaluation involved the determination of weight, measured height and estimated height, the former two of which were performed following the recommendations of the Brazilian Ministry of Health.[4] Weight was determined using a portable electronic scale (Filizola Personal Line, São Paulo, Brazil) with a capacity of 180 kg and precision of 100 g. Height was measured using a portable stadiometer (Cardiomed® WCS, Curitiba, Brazil) with a maximum capacity of 216 cm and precision of 1 mm. Children who could not walk were weighed while being held by an accompanier and the child's weight was determined by subtracting the weight of the accompanier from the total weight of the two individuals. In such cases, height was estimated based on the height to the knee, which was determined using bone calipers (Cescorf, Porto Alegre, Brazil) with the child in the supine position and the knee flexed at 90°. Height was then estimated using a specific equation for patients with motor disabilities aged two to 12 years: height (cm) = (2.69 x height to knee) + 24.2.[5]

The growth curves recommended by the World Health Organization[6,7] were used for the comparison of the weight and height measures with the aid of the WHO AnthroPlus® program, version 3.2.2. The following indices were used: height for age (H/A), weight for age (W/A) and body mass index for age (BMI/A). These indices were used to classify the children based on z-scores: short H/A (ZH/A < -2 z-scores), underweight (ZW/A and ZBMI/A < -2 z-scores) and ideal range (ZW/A and ZBMI/A ≥ -2 and ≤ +1 z-scores). Independently of age, ZW/A and ZBMI/A > +1 were used for

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the classification of overweight. All measurements were made three times and the mean was calculated from the two closest measurements.

2.3 BODY COMPOSITION

Electrical bioimpedance was determined using the Maltron BF-906 analyzer (Maltron, United Kingdom) with four surface electrodes and a frequency of 50 Hz in alternating current. The child was placed in the supine position on a non-conductive surface with arms and legs in abduction at 45°. Two electrodes separated by a distance of 5 cm were positioned on the dorsum of the right hand (third metacarpus and wrist) and two were placed on the dorsum of the right foot (third metatarsus and ankle). The children were evaluated barefoot with minimal clothing and the removal of all metallic accessories. To ensure the accuracy of the reading, the guardians were instructed to follow some prior procedures based on Heyward & Stolarczyk.[8]

Total body water was estimated based on the measures of impedance and height with the aid of equations that have been validated for patients with CP.[9] Fat-free mass (FFM) was determined by dividing total body water by specific hydration factors for sex and age group.[10] Fat mass (FM) was determined by subtracting FFM from body weight. Due to the height deficit common to children with CP, FFM and FM were adjusted for height following the model proposed by Wells & Cole (2002).[11] The division of these two measures by height squared ($FFM/height^2$ and $FM/height^2$) determined the fat-free mass index (FFMI) and fat mass index (FMI). The percentage of fat mass (%FM) was determined by the following equation: %FM = (FMI/weight) x 100.

FFMI reference values were used to compare the body composition of the children with CP to that of healthy children.[12] Excess FM was diagnosed using the criteria proposed by Lohman (1987),[13] in which rates higher than 18% and 25% for boys and girls, respectively, were classified as excess fat.

2.4 FOOD CONSUMPTION

The evaluation of calorie and macronutrient intake was performed using a 24-hour log. The Dietary Reference Intakes proposed by the US Food and Nutrition Board in 2002[14] were used to estimate the prevalence of inadequacies with regard to calorie, protein and carbohydrate intake. A second 24-hour log from a random selection of 20% of the children was used to determine intra-individual variations in food intake.

The adjustment of the distribution of calorie, protein and carbohydrate intake was performed with the removal of the effect of intra-individual variability using the method proposed by Iowa State University.[15,16] The prevalence of inadequate calorie, protein and carbohydrate intake corresponded to the proportion of individuals whose intake was below the estimated energy requirement and

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estimated average requirement.[14] Calorie and nutrient intake was estimated with the aid of the NutWin software program. Excessive calorie intake was calculated based on the mean need of the participants + 2 standard deviations (SD).

As there is no mean estimated lipid requirement (only adequate intake), it was not possible to estimate the proportion of inadequate intake. Thus, the evaluation was performed using the acceptable distribution range as reference.[14]

The age groups recommended for the Dietary References Intakes are one to three years and four to eight years.[14] Therefore, the sample was subdivided into two groups based on the age range of the children in the present study (three years and four to seven years).

2.5 STATISTICAL ANALYSIS AND ETHICAL ASPECTS

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS for Windows version 13.0, SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test determined that all data demonstrated Gaussian (normal) distribution. Thus, Pearson's correlation coefficients were calculated for the determination of correlations between variables. The chi-square test was used to investigate associations between excessive calorie intake and both excess weight and body fat. A p-value < 0.05 was considered indicative of statistical significance.

This study received approval from the Human Research Ethics Committee of *Universidade Federal de Pernambuco*, Brazil (certificate number: 63607416.7.0000.5208). The guardians received clarifications regarding the objectives and procedures of the study and those who agreed to the participation of their children signed a statement of informed consent authorizing the publication of the results.

3 RESULTS

Fifty-three children (mean age: 4.6 ± 1.2 years) participated in the study, 36 of whom were in the four to seven-year-old age group and 32 were boys. A total of 73% of the families had an income of 0.5 times the Brazilian monthly minimum wage and 79.2% did not receive any government benefits. The mother was the main caregiver in 88.7% of cases and 57.2% of mothers had a high school education or higher.

Table 1 displays the clinical and nutritional characteristics of the sample. Table 2 shows that there was no statistically significant association between excess weight and excess FM or FFM. Moreover, no significant association was found between excessive calorie intake and excess weight, FM or FMM.

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Table 1 – Clinical and nutritional characteristics of children with cerebral palsy attended at three rehabilitation centers

Clinical characteristics	Sample (n = 53)	
	n	**%**
Type of CP[•]		
Spastic	44	83.0
Other	9	16.9
GMFCS[♦]		
I	15	28.3
II	17	32.1
III	21	39.6
Height for age z-score (ZH/A)[□]		
Height deficit (< -2 z-scores)	04	7.5
Adequate height (≥ -2 z-scores)	49	92.5
Mean ± SD	-0.3 ± 1.6	
Weight for age z-score (ZW/A)[□]		
Underweight (< -2 z-scores)	04	7.5
Ideal range (≥ -2 and ≤ -1 z-score)	38	71.7
Excess weight ($> +1$ z-score)	11	20.8
Mean ± SD	-0.2 ± 1.5	
BMI[*] for age z-score (ZBMI/A)[□]		
Underweight (< -2 z-scores)	03	5.7
Ideal range (≥ -2 and ≤ -1 z-score)	34	64.2
Excess weight ($> +1$ z-score)	16	30.2
Mean ± SD	0.2 ± 1.8	
Weight and height data		
Weight (Kg) Mean ± SD	17.7 ± 4.9	
Height (m) Mean ± SD	1.05 ± 0.08	
Fat-free mass index (FFMI)[□]		
FFMI (Kg/m^2) Mean ± SD	11.7 ± 2.0	
FFMI (%) Mean ± SD	69.0 ± 7.8	
Fat-free mass index (FFMI)[□]		
Deficit (< -2 z-scores)	36	67.9
No deficit (≥ -2 z-scores)	17	32.1
Fat mass index (FMI)		
FMI (Kg/m^2) Mean ± SD	6.9 ± 1.6	
FMI (%) Mean ± SD	31.0 ± 7.8	
Fat mass index (FMI) (%)[º□]		
No excess	12	22.6
Excess	41	77.4

[•]CP: cerebral palsy; [♦]GMFCS: Gross Motor Function Classification System; [*]BMI: body mass index. [º]Excess $> 18\%$ for boys and $> 25\%$ for girls; [□]No statistically significant difference between sexes

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Table 2 – Excess fat mass and fat-free mass according to occurrence of excess weight and excessive calorie intake among children with cerebral palsy attended at three rehabilitation centers

	Excess weight (ZBMI/A)				p•
Fat mass index (FMI) (%)	Yes		No		0.737*
No excess	03	18.7	09	24.3	
Excess	13	81.2	28	75.7	
Fat-free mass index (FFMI) (%)					
Between 1st and 2nd tertile	14	87.5	21	56.7	0.064
Above 3rd tertile	02	12.5	16	43.2	
	Excessive calorie intake (Kcal)				
Excess weight (ZBMI/A)	Yes		No		0.813
No excess	11	64.7	26	72.2	
Excess	06	35.3	10	27.8	
Fat mass index (FMI) (%)					0.490*
No excess	05	29.4	07	19.4	
Excess	12	70.6	29	80.5	
Fat-free mass index (FFMI) (%)					0.865
Between 1st and 2nd tertile	12	70.6	23	63.9	
Above 3rd tertile	05	29.4	13	36.1	

•chi-square test; * Fisher's exact test

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Table 3 – Correlation matrix for anthropometric, body composition and dietary variables among children with cerebral palsy attended at three rehabilitation centers Pearson's correlation test; *significance level p < 0.05; ** significance level p < 0.01

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Age	-										
2. Mobility	0.140	-									
3. ZBMI/A	0.185	-0.115	-								
4. ZH/A	-0.346*	0.273*	-0.026	-							
5. Height (m)	0.721**	0.355**	0.152	0.388**	-						
6. Fat mass index	0.401**	-0.003	0.965**	-0.015	0.356*	-					
7. Fat-free mass index	0.284	-0.093	0.971**	-0.111	0.177	0.980**	-				
8. Calories	0.100	0.186	-0.031	-0.055	0.045	-0.005	-0.003	-			
9. Proteins (g)	0.003	0.146	-0.106	-0.021	-0.003	-0.054	-0.056	0.736**	-		
10. Carbohydrates (g)	-0.029	0.172	-0.132	-0.142	-0.135	-0.142	-0.110	0.854**	0.467**	-	
11. Lipids (g)	0.312*	0.120	0.225	0.125	0.376**	0.316*	0.262	0.682**	0.505**	0.268	-

The data in Table 3 show that there was collinearity in the following pairs of variables: ZBMI/A and FMI (r = 0.965), ZBMI/A and FFMI (r = 0.971) as well as FMI and FFMI (r = 0.980). ZH/A was negatively correlated with age and positively correlated with mobility. Height was positively correlated with age, mobility and ZH/A. FMI was positively correlated with age and height. With regard to food intake variables, only lipids demonstrated positive correlations with age, height and FMI.

Table 4 shows that there were no statistically significant differences in calorie and macronutrient intake between the three-year-old and four-to-seven-year-old age groups. However, a statistically significant difference was found with regard to protein requirement, which was higher in the children aged four to seven years (p = 0.007). No significant difference was found with regard to protein intake, but intake was well above the requirement. These data demonstrate that calorie and macronutrient intake was similar in the sample independently of age group.

In the three-year-old group, 32.1% had inadequate calorie intake, 0.70% had inadequate protein intake and 0.20% had inadequate carbohydrate intake. Among the four-to-seven-year-old children, 29% had inadequate calorie intake, 0.40% had inadequate protein intake and 0.10% had inadequate carbohydrate intake. These results demonstrate calorie and macronutrient intake well above the needs of the two groups.

Table 4 – Calorie and macronutrient intake according to estimated energy requirements, requirements in grams and acceptable macronutrient distribution range (AMDR%) among children with cerebral palsy attended at three rehabilitation centers

	3 years (n = 17)	4 to 7 years (n = 36)	p*
Calorie requirement (Kcal) (Mean ± SD)	1179 ± 73	1230 ± 126	0.074
Calorie intake Kcal (Mean ± SD)	1326 ± 352	1414 ± 424	0.462
% with excessive calorie intake ⧫	47.1	52.8	0.925**
Protein requirement (grams/day)	13.2 ± 2.1	16.5 ± 4.7	0.007
Protein requirement – AMDR (%)	5-20	10-30	-
Protein intake (grams/day)	57.8 ± 21.1	60.1 ± 18.6	0.683
Protein intake (%)	17.5 ± 4.9	17.4 ± 3.9	0.918
Carbohydrate requirement (grams/day)	100	100	-
Carbohydrate requirement – AMDR(%)	45-65	45-65	-
Carbohydrate intake (grams/day)	181.7 ± 59.0	184.4 ± 57.5	0.873
Carbohydrate intake (%)	54.2 ± 9.2	52.5 ± 8.7	0.641
Lipid requirement – AMDR (%)•	30-40	25-35	-
Lipid intake (%)	32.1 ± 15.0	38.4 ± 17.0	0.191

* Student's t-test   ** chi-square test ⧫intake above mean of calorie requirement + 2 SD = more than 1325 Kcal (3 years) and more than 1482 Kcal (4 to 7 years) • no estimated average requirement reference for lipids

4 DISCUSSION

The nutritional status of the children with CP was similar to that reported in the *III Pesquisa Estadual de Saúde e Nutrição* (III PESN [Third State Health and Nutrition Survey]) conducted in the state of Pernanbuco, Brazil in 2006,[17] which revealed height deficit in 7.7% of children less than five years of age. In the present study, height deficit was found in 7.5% of the children. The data in the survey on W/A (3.0%) and BMI/A (1.9%) reveal that the problem of childhood malnutrition in

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Pernambuco is practically at the control threshold (2.3%). The data in the present study on W/A (7.5%) and BMI/A (5.7%) show that underweight is a problem with these children, demonstrating that the process of nutritional transition is occurring, but at a slower rate in children with CP less than five years of age.

The III PESN[17] revealed that 8.8% of children less than five years of age in the state of Pernambuco had excess weight based on BMI/A ≥ + 2 z-scores. Using the same cutoff point, the prevalence in the present study was 9.8%. As the prevalence in a healthy population should not surpass 2.3%, the problem of excess weight in the children with CP is worrisome and reflects what is occurring in the child population as a whole. In contrast, Pascoe et al. (2016)[18] found a lower prevalence rate of excess weight among children with CP compared to those with typical development. However, studies conducted in the United States,[19] Korea[20] and China[21] found no differences in the prevalence of excess weight among children with CP compared to children in general. This lack of a difference may be explained by the fact that the individuals in the studies cited belonged to the group with lower motor impairment.

The prevalence of excess weight (BMI/A ≥ +2 z-scores) in the literature ranges from 5.8% to 16.5%.[19,20,21] This variation may be due to the methodological differences in the studies. Nonetheless, all these rates surpass the expected prevalence in a healthy population (2.3%).

Children with CP, especially those with more impairments, demonstrate lower linear growth.[22] However, this was not confirmed in the present investigation, as the prevalence of short height was similar to that reported in the state survey (III PESN).[17] Moreover, a positive correlation was found between age and height, whereas a negative correlation was found between age and ZH/A, demonstrating that the children gained height with age, but not enough to maintain them on the ZH/A curve.

In recent years, an increase has been found in excess weight and body fat in less impaired children with CP who are relatively inactive.[19,20] In the present sample, besides the high frequency of excess weight (30.1% above the +1 z-score), 77.4% exhibited excess body fat, indicating that this problem affects even children classified in the ideal range for BMI. It is noteworthy that no association was found between excess weight and body fat, possibly due to the homogeneity of the sample in terms of body composition. In contrast, Walker et al. (2015)[23] found that children with moderate CP had lower levels of FFM compared to those with mild CP.

No correlations were found between mobility and anthropometric variables. This finding may have been due to the homogeneity of the sample in terms of mobility.

The findings demonstrate that the majority of the children exhibited lean mass deficit, which, according to the literature, may be directly related to inadequate linear growth as well as the depletion

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of muscle and atrophy due to disuse.[23] Factors such as the suppression of growth hormone as well as reductions in muscle sarcomeres, fiber size and muscle capacity for longitudinal and transverse growth may further aggravate this condition.[24]

No differences in body composition were found according to the degree of mobility. However, the literature reports that children with mild CP have more FFM and a lower percentage of body fat compared to individuals with more severe CP.[1,23] A recent study found that children with CP on all levels of mobility had quantities of excess fat and FFM below the mean in comparison to normal children, but weight and BMI were similar.[1] The same study reports a positive correlation between calorie intake and FFM, especially in less impaired children, which is in agreement with data described by Walker et al. (2012),[2] suggesting the hypothesis that children with a higher level of physical activity have greater FFM and, therefore, more energy consumption due to the greater need. However, this was not confirmed in the present study, as demonstrated by the lack of a correlation between these variables.

With regard to food intake, no correlations were found between calorie intake or macronutrient intake (with the exception of lipids) and anthropometric variables (ZBMI/A, FMI and FFMI). This lack of correlation may have been due to the inherent bias of food intake measurement techniques, with the possible underestimation of calorie and macronutrient intake. A previous study found that children with CP on all levels of mobility demonstrated similar anthropometric variables, body composition, calorie intake and macronutrient intake compared to children with typical development.[2]

The results also reveal quite homogeneous food intake in the sample, as mean calorie and macronutrient intake was similar between the two age groups and above their requirements. Mean calorie intake above the requirements is also demonstrated by the fact that excessive calorie intake was found in nearly 50% of the sample. Moreover, protein and carbohydrate intake corresponded to threefold and twofold the requirements, respectively. This high intake could explain the high prevalence of excess weight encountered. However, no statistically significant association was found between excess weight and the occurrence of excessive calorie intake. It is possible that the small sample size impeded the determination of such an association. The finding with regard to the high-protein diet is in agreement with data reported in some studies.[2,25] Moreover, there were no cases of inadequate protein or carbohydrate intake. With regard to lipids, it was not possible to determine inadequacy due the absence of estimated average requirement values.

Among 16 studies published between 2003 and 2013 analyzed in a systematic review on food intake among Brazilian children,[26] four reported calorie intake above the requirements and three

reported deficient calorie intake. However, it is difficult to compare results regarding excessive calorie intake with the present findings due to methodological differences in the evaluation of intake.

The prevalence of inadequate calorie intake was close to 30%. In a study with a similar methodology performed with data from the Second State Health and Nutrition Survey conducted in Pernambuco in 1997, Fidelis & Osório[27] found high percentages of inadequate calorie intake (55.2% among children aged four and five years). As these data are from 20 years ago, the prevalence of inadequacy should currently be much lower, perhaps around the 30% found in the present study.

The findings demonstrate that the food intake of the children with CP in the present study did not differ significantly from that of children with typical development. However, other investigations found that children with CP had lower intake than children in general and that this situation was further aggravated by the increase in the degree of motor impairment.[2,25] Another possible explanation for the findings is that there is no justification for a reduction in calorie intake among the children in the present study, as none had any problems related to chewing or swallowing and all fed themselves in an independent manner. The 30% prevalence rate of inadequate calorie intake may be associated with the unfavorable socioeconomic status of some families, although the majority of mothers had a good level of schooling.

The limitation of the present study was the use of a convenience sample from three rehabilitation centers, which implies a reduction in the possibility of extrapolating the findings to the population of children with CP in general.

5 CONCLUSION

The nutritional status and food intake of the children with CP in the present study were similar to those of children with no neurological impairment, possibly due to the fact that the children evaluated did not exhibit severe motor impairment. Further studies are needed to investigate what parameters and reference standards would be more adequate for the nutritional assessment of less impaired children with cerebral palsy. Investigations with quantitative and qualitative evaluations of food intake in the population are also needed, as such studies are scarce in the literature.

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