Nutrición Hospitalaria
ISSN: 0212-1611
nutricion@grupoaran.com
Sociedad Española de Nutrición Parenteral y Enteral
España

García-Iñiguez, Jorge Abraham; Vásquez-Garibay, Edgar Manuel; García-Contreras, Andrea; Romero-Velarde, Enrique; Troyo-Sanroman, Rogelio
Assessment of anthropometric indicators in children with cerebral palsy according to the type of motor dysfunction and reference standard
Nutrición Hospitalaria, vol. 34, núm. 2, marzo-abril, 2017, pp. 315-322
Sociedad Española de Nutrición Parenteral y Enteral
Madrid, España

Nutr Hosp. 2017; 34(2):315-322 ISSN 0212-1611 - CODEN NUHOEQ S.V.R. 318

Nutrición Hospitalaria

Trabajo Original

Pediatría

Assessment of anthropometric indicators in children with cerebral palsy according to the type of motor dysfunction and reference standard

Evaluación de indicadores antropométricos en niños con parálisis cerebral de acuerdo con el tipo de disfunción motora y estándar de referencia

Jorge Abraham García-Iñiguez[1], Edgar Manuel Vásquez-Garibay[1,2], Andrea García-Contreras[1], Enrique Romero-Velarde[1,2] and Rogelio Troyo-Sanroman[1]

[1]Instituto de Nutrición Humana. Universidad de Guadalajara. Jalisco, Mexico. [2]Hospital Civil de Guadalajara "Dr. Juan I. Menchaca". Jalisco, Mexico

Abstract

Aim: The study aimed to demonstrate that the assessment of the anthropomorphic measurements of children with cerebral palsy (CP) varies according to the type of motor dysfunction and references standard used for comparison.

Method: In a cross-sectional design, 108 children 2 to 16 years were classified according to the type of motor dysfunction by gender and age group. Weight, mid-upper-arm-circumference (MUAC), and alternative measures for height were performed. Height/age and weight/age indexes and BMI were evaluated with percentiles and/or Z-scores with reference to a number of previously published references of growth, including those of the World Health Organization (WHO).

Results: Fifty-three (49.1%) were females and 55 (50.9%) males. Spastic type was predominant (73.1%) and 26.9% were other types of dysfunction. Most of the children were located on level IV (14.6%) and level V (73.1%) of the Gross Motor Function Classification System (GMFCS). Significant differences were found, suggesting that weight ($p = 0.002$), height ($p = 0.001$), and MUAC ($p = 0.05$) are higher in the spastic group than in other groups.

Conclusions: The anthropometric indicators were significantly higher in the spastic group than in other groups. Upper-arm length (UAL) seemed less appropriate than knee height (KH) and lower-leg length (LLL) for measuring height. The WHO reference standard was not useful to evaluate the majority of anthropometric indexes in children with CP, other references as the growth charts of Day and Brooks have been more suitable.

Key words:

Cerebral palsy. Children. Spastic quadriplegia.

Resumen

Objetivo: demostrar que la evaluación de las mediciones antropomórficas de los niños con parálisis cerebral (PC) varía según el tipo de disfunción motora y la referencia estándar utilizada.

Método: en un diseño transversal se incluyeron 108 niños de 2 a 16 años clasificados de acuerdo con el tipo de disfunción motora por sexo y grupos de edad. Se obtuvieron el peso, circunferencia media de brazo y mediciones alternas para la talla. Los índices talla/edad, peso/edad y el IMC fueron evaluados con los percentiles y/o puntuaciones Z con referencia a estándares de crecimiento previamente publicados, incluyendo los de la Organización Mundial de la Salud (OMS).

Resultados: cincuenta y tres (49.1%) eran mujeres y 55 (50.9 %) hombres. Predominó la PC tipo espástico (73.1%) y 26.9% otros tipos de disfunción. La mayoría de los niños se encontraron en el nivel IV (14.6%) y en el nivel V (73.1 %) de la Gross Motor Function Classification System (GMFCS). Se encontraron diferencias significativas, lo que sugiere que el peso ($p = 0,002$), talla ($p = 0,001$), y la circunferencia media del brazo CMB ($p = 0,05$) son mayores en el grupo espástico que en otros grupos.

Conclusiones: los indicadores antropométricos fueron mayores en el grupo espástico. La longitud del brazo pareció menos apropiada que la altura de la rodilla y la longitud de la pierna para la medición de la talla. El estándar de crecimiento de la OMS no resultó útil para evaluar los índices antropométricos en niños con parálisis cerebral; otras referencias como las tablas de crecimiento de Day y Brooks fueron más adecuadas.

Palabras clave:

Parálisis cerebral. Niños. Cuadriplejia espástica.

Received: 14/07/2016
Accepted: 07/12/2016

García-Iñiguez JA, Vásquez-Garibay EM, García-Contreras A, Romero-Velarde E, Troyo-Sanroman R. Assessment of anthropometric indicators in children with cerebral palsy according to the type of motor dysfunction and reference standard. Nutr Hosp 2017;34:315-322

DOI: http://dx.doi.org/10.20960/nh.353

Correspondence:

Edgar M. Vásquez Garibay. Instituto de Nutrición Humana. Hospital Civil de Guadalajara Dr. Juan I. "Menchaca". Salvador Quevedo y Zubieta # 350, Col. Independencia. CP 44340 Guadalajara, Jalisco México
e-mail: vasquez.garibay@gmail.com

INTRODUCTION

Infantile cerebral palsy (CP) is the most common cause of motor disability in children and refers to the syndrome caused by injuries to the central nervous system in early stages of development (1). Food shortage is a common problem that causes multiple nutritional deficiencies that ultimately lead to protein-energy malnutrition, especially in patients with more severe neurological conditions (2,3). This syndrome of malnutrition is associated with poor growth, which generally depends on the type and distribution of dysfunction and its severity; however exist non nutritional factors that can be associated to malnutrition (4). It has also been observed that overweight and obesity are common comorbidities in children with neurological damage (5-6).

The assessment of nutritional status in children with CP is hard because of the difficulty in obtaining reliable measurements of basic data such as weight, height, and body mass index (BMI), which may cause an incorrect interpretation and analysis of data to identify children with nutritional risk and prevent a proper diagnosis. This difficulty is due to the presence of joint contractures, muscle atrophy, and movement disorders common in these patients (7). Furthermore, anthropometric data obtained should be compared with special reference standards for this population. Apparently, the problem of measurement of height in this group of patients has been overcome by the use of alternative measures (8,9).

There are different growth charts for assessing the nutritional status of children with CP. Day et al. (10) published these for weight and linear growth of children and adolescents 2 to 20 years of age with CP. Anthropometric indicators included weight for age, height for age, and body mass index. Growth curves for each indicator were prepared separately for different levels of disability (according to gross motor skills and feeding ability). There are others growth charts that have also been used such as specialized growth curves (11), using the Gross Motor Function Classification System (GMFCS) (8,12-17) and the use of percentiles for growth assessment with alternative measures (18); and, there are studies evaluating children with CP by using reference standards for healthy children (2,4,16,19,20). However, it has been recognized that children with CP cannot be evaluated with reference standards for healthy children because most of them have linear growth retardation and/or an altered body composition (21). For example, using the reference of the National Center for Health Statistics of the Centers for Disease Control and Prevention (NCHS/CDC), the probable malnutrition becomes excessively elevated to 80% (2). The aforementioned CP-specific growth charts by Day et al. and Brooks et al., as well as the others utilizing non-standard growth parameters, shed much light on this, and on the fact that level of disability plays a significant role in determining growth patterns for children and adolescents with CP. However, the question of whether type of motor dysfunction might also play a role has not been considered. Therefore, the purpose of this study was to demonstrate that the assessment of the anthropomorphic measurements of children with cerebral palsy (CP) varies according to the type of motor dysfunction and references standard used for comparison.

METHODS

A cross-sectional design included 108 children (53 females and 55 males) from 2 years to 16 years, nine months (7y 9m ± 4y 3m), who attended the outpatient pediatric clinic at the Civil Hospital of Guadalajara "Dr. Juan I. Menchaca." They were divided into three age groups: preschoolers (24-71 months), schoolchildren (72-119 months), and adolescents (≥ 120 months). CP patients with any type of dysfunction were included, diagnosed and classified by a pediatric neurologist according to the GMFCS (22). The sample size was determined and calculated with a confidence level of 95% (α 0.05) $[(Z_{\alpha}/_{2}^{2})\ (p(1-p)]/d^2$ assuming a probability of 50% malnutrition (20).

PARTICIPANTS

Patients with diagnoses unrelated to CP (Down syndrome, autism, degenerative disorders); use of medications that could alter body composition (steroids, thyroxine, anti-retrovirals); and those with CP of postnatal origin (traumatic injuries, accidents, tumors, other injuries) were not included. Three cases, two incomplete files, and one with CP secondary to an accident were excluded. Informed consent from the parents or legal caregivers of the children for participation in this study was obtained.

ANTHROPOMETRIC MEASUREMENTS

The weight of the children with CP was obtained with clean diaper and as little clothing as possible on a SECA scale (model 700, Hamburg, Germany), to the nearest 50 g. The child was weighed in the arms of a family member or observer, after which only the adult was weighed, and the difference of the weights was obtained. For the measurement of the length two observers were previously standardized. The length was estimated using the Lower-leg length (LLL) and was obtained with a tape (Seca 206, Hamburg, Germany); it was measured from the line of the inner knee joint to the lower border of the malleolus of the tibia at an angle of 90°; knee height (KH) and upper-arm length (UAL) were obtained with a segmometer (Rosscraft segmometer, Canada) according to the techniques proposed by Stevenson (9). KH measurement was performed with the knee flexed to 90° in a straight line with the heel. It was measured from the proximal end of the patella to the bottom of the heel; UAL was measured with the arm relaxed at the side of the trunk. It was measured from the lateral edge of the acromion to the radial head. The alternative measurements equations are shown next: LLL = (3.26 × LLL) + 30.8; KH = (2.68 × KH) + 24.2; UAL = (4.35 × UAL) + 21.8.

A flexible tape (Seca 206, Hamburg, Germany) was used to measure the mid-upper-arm circumference (MUAC) and was measured at the midpoint of the length of the arm from the acromion to the olecranon. The Lange caliper (Cambridge, Maryland), which has a sensitivity of 1 mm, was used for the measurement of skin folds. The triceps skinfold (TSF) was obtained at the midpoint

of the left arm in its internal backside. The measurement was performed in triplicate and the average of the three measurements was obtained. The subscapular skinfold (SSF) was obtained from the bottom corner of the left scapula; this measurement was performed in triplicate and the average was obtained. Anthropometric indexes weight/age (W/A), height/age (H/A), and BMI according to the growth charts of Day (10), Brooks (17) and WHO reference (23,24) were estimated. Subjects were considered normal when indicators were found between the 10th and 90th, malnourished below the 10th percentile, and overweight above the 90th percentile according to the BMI growth charts of Day. Z scores with the WHO reference standard were also obtained (23,24).

STATISTICAL ANALYSIS

Student's t-test, Mann-Whitney U, single-factor ANOVA for comparison of averages, and post hoc comparisons for multi-quantitative variables were performed. Chi-square test and Fisher's exact test for qualitative variables were performed. Significant results were expressed as odds ratios to identify the likelihood of epidemiological meaning. For statistical analysis, SPSS version 20 (SPSS Inc., Chicago, IL, USA) was used.

ETHICAL CONSIDERATIONS

The protocol does not put at risk the participant of study and adhered to the guidelines of the Declaration of Helsinki and principles of beneficence, non-maleficence, justice, and autonomy of decision. The protocol was approved by the ethics committee of the Hospital Civil de Guadalajara "Dr. Juan I. Menchaca" No. 1344/14.

RESULTS

The first part of table I shows the frequency of the type of dysfunction in children with CP; spastic type predominated with 73.1% of cases. The second part of the table shows the classification with the growth charts of Day (10). Most children belonged to group 3 (46.3%), which have important brain dam-

Table I. Distribution according to the type of motor dysfunction, Day and GMFCS Classifications

Type of dysfunction	n	%				
Spastic	79	73.1				
Ataxic	1	0.9				
Dyskinetic	3	2.8				
Hypotonic	11	10.2				
Mixed	14	13				
	Spastic		Others		Total	
Day Classification[1,3]	n	%	n	%	n	%
Day 1	7	8.9	1	3.4	8	7.4
Day 2	6	7.6	0	0	6	5.6
Day 3	33	41.8	17	58.6	50	46.3
Day 4	6	7.6	5	17.2	11	10.2
Day 5	27	34.2	6	20.7	33	30.6
GMFCS Classification[2,3]	n	%	n	%	n	%
GMFCS I	4	5.1	1	3.4	5	4.6
GMFCS II	6	7.6	0	0	6	5.6
GMFCS III	2	2.5	0	0	2	1.9
GMFCS IV	10	12.7	6	20.7	16	14.8
GMFCS V	57	72.2	22	75.9	79	73.1
Total	108	100	108	100	108	100

[1]Day classification (10): Group 1. Walks well alone at least 20 feet, balances well; Group 2. Walks with support or unsteadily alone at least 10 feet; Group 3. Crawls, creeps, or scoots but does not walk; Group 4. Does not walk, creep, or scoot, does not feed self, no feeding tube; Group 5. Does not walk, creep, or scoot, does not feed self, feeding tube. [2]GMFCS Classification (17): I. Walks without limitations; II. Walks with limitations; III. Walks using a hand-held mobility device; IV. Self-mobility with limitations, may use powered mobility; V. Transported in a manual wheelchair. [3]Fisher's exact test; Day classification by spastic vs. others p = 0.124; and GMFCS classification by spastic vs. others p = 0.479.

age; and group 5 (30.6%) refers to children with severe neurological deterioration and who require the use of gastrostomy. Both levels included 76.9% of cases. The third part of the table shows the distribution with the GMFCS classification (22). More than 70% of the children belonged to level V. Table II shows the comparison of anthropometric data in children with spastic CP versus other types of dysfunction. Significant differences in favor of spastic type to have higher weight (p = 0.002) and greater height estimated by LLL (p = 0.001), KH (p = 0.001), UAL (p = 0.002), and MUAC (p = 0.05) were observed. Table III shows

Table II. Anthropometric indicators of children with spastic CP and other CPs

	Spastic (n = 79)			Others (n = 29)			
	Mean (SD)	Limit		Mean (SD)	Limit		p[1]
Age in months	101.4 (50.3)	24	201	79.8 (51.6)	27	203	0.011
Weight (kg)	17.4 (7.3)	7	37	13.7 (7.0)	7	35.5	0.002
[2]Height by LLL (cm)	110.5 (18.7)	72.2	168.4	98.4 (18.0)	78.1	157.9	0.001
[2]Height by KH (cm)	111.2 (18.6)	78	169.5	98.3 (18.8)	77.2	158.7	0.001
[2]Height by UAL (cm)	124.7(21.7)	85.3	192.3	110.9 (19.4)	85.7	167.1	0.002
KH (cm)	32.3 (6.9)	20	54	27.5 (7.0)	19.7	50	< 0.001
LLL (cm)	24.4 (5.7)	12.7	42.2	20.7 (5.5)	14.5	39	0.001
UAL (cm)	23.7 (5.0)	14.6	39.2	20.5 (4.5)	14.7	33.4	0.002
BMI by LLL	13.7 (2.6)	8.3	22.0	13.5 (3.1)	8.9	23.8	0.449
BMI by KH	13.5 (2.5)	8.8	23.7	13.5 (3.3)	9.0	22.5	0.665
BMI by UAL	10.7 (1.8)	6.8	16.0	19.6 (2.5)	7.3	18.2	0.378
MUAC (cm)	15.4 (2.9)	11	23	14.6 (4.4)	8.5	28.8	0.05
TSF (mm)	6.6 (3.5)	2	18	6.2 (4.7)	2	22	0.152
SSF (mm)	5.2 (2.9)	2	17	4.6 (3.1)	1	16	0.113

KH: Knee height; LLL: Lower leg length; UAL: Upper arm length; BMI: Body mass index; MUAC: Mid-upper-arm circumference; TSF: Triceps skinfold; SSF: Subscapular skinfold; [1]Mann-Whitney U. [2]Student t test: spastic vs. others with LLL, KH, UAL p < 0.005. Spastic: LLL vs. UAL p < 0.001; KH vs. UAL p < 0.001; others: LLL vs. UAL p < 0.001; KH vs. UAL p < 0.001; when compared LLL vs. UAL and KH vs. UAL by gender p < 0.001.

Table III. Anthropometric data by age group

	Age group			
	24-71 m n = 46	72-119 m n = 30	≥ 120 m n = 32	p[1]
	Mean (SD)	Mean (SD)	Mean (SD)	
Weight (kg)	11.9 (4.0)	17.5 (6.2)	21.8 (8.2)	< 0.001
Height by LLL (cm)	92.3 (9.2)	110.6 (12.4)	125.5 (18.0)	< 0.001
Height by KH (cm)	93.1 (9.8)	110.6 (13.5)	126.0 (18.0)	< 0.001
Height by UAL (cm)	104.3 (12.0)	125.5 (14.8)	140.7 (20.3)	< 0.001
BMI by LLL (kg/cm^2)	13.6 (2.4)	14.0 (3.4)	13.4 (2.5)	0.731
BMI by KH (kg/cm^2)	13.4 (2.7)	14.0 (3.2)	13.3 (2.3)	0.582
BMI by UAL (kg/cm^2)	10.7 (1.8)	10.8 (2.4)	10.7 (1.9)	0.952
MUAC (cm)	14.2 (3.2)	15.9 (3.2)	16 (3.3)	0.025
TSF (mm)	6.1 (3.2)	8.1 (4.7)	5.6 (3.3)	0.024
SSF (mm)	4.5 (2.6)	5.8 (3.6)	5.1 (2.7)	0.176

[1]One-way ANOVA. LLL: Lower-leg length; KH: Knee height; UAL: Upper-arm length; BMI: Body mass index; MUAC: Mid-upper-arm circumference; TSF: Triceps skinfold; SSF: Subscapular skinfold. Post Hoc test (T3 Dunett): weight between age groups 24-71 vs. *72-119 and 24-71* vs. *≥ 120 months p = 0.001; 72-119* vs. *≥ 120 months p = 0.059; height estimated by alternative measures between groups 24-71* vs. *72-119 and 24-71* vs. *≥ 120 months, 72-119* vs. *≥ 120 months p < 0.005; MUAC 24-71* vs. *120 p = 0.060; TSF 72-119* vs. *≥ 120, p = 0.064.*

significant differences among the three age groups for weight; height estimated by LLL, KH, and UAL ($p < 0.001$); and MUAC ($p = 0.025$) and TSF ($p = 0.024$). Post hoc tests showed significant differences in weight between the age groups of 24-71 and 72-119 months and 24-71 and ≥ 120 months and in height estimated by alternative measures among the three age groups. The MUAC was lower in the 24-71 months age group than in the ≥ 120 months ($p = 0.060$) group, although the thickness of TSF was higher in the 72-119 group than in the ≥ 120 months group ($p = 0.064$).

Table IV shows according to the BMI, using the Day reference standard, 31.5% of the total population was below the 10th percentile. It was observed that the group of children with "other types" of dysfunction showed a significantly higher frequency of BMI below the 10th percentile than the spastic group (41.4% *vs.* 27.8%, respectively) [OR 20.1 (4.1, 98.4), $p < 0.001$]. Females (35.8%) were more affected (were below the 10th percentile) than males (27.3%) and, when we compared the age groups, children of 72-119 months of age were more affected (43.3%) than the other two age groups, 24-71 (26.1%) and ≥ 120 months of age (28.1%), [OR 2.07 (0.86, 4.99), $p = 0.10$]. The same table shows the height/age index of the total population. It shows that 88.9% are between the 10th and 90th percentiles. No significant association was observed between height/age index deficit and females ($p = 0.058$). Likewise, a significantly increased probability of deficit appears in the height/age index in children older than 120 months compared with children of 24-71 and 72-119 months of age [OR = 6.9 (1.2-37.4), $p = 0.023$]. Figure 1A shows the anthropometric indexes of height/age, weight/age, and BMI according to the WHO reference standard (23,24). It is noted that the vast majority of cases is below -2 SD regardless of sex, age, and the type of dysfunction.

Table IV. BMI and height/age according to the Day growth charts by type of dysfunction, sex and age group

Variable	Percentile < 10	Percentile 10-90	Percentile > 90
	n (%)	n (%)	n (%)
Body mass index			
Type of dysfunction			
Spastic (n = 79)	22 (27.8)	56 (70.9)	1 (9.3)
Others (n = 29)	12 (41.4)	15 (51.7)	2 (6.9)
Sex			
Female (n = 53)	19 (35.8)	32 (60.4)	2 (3.8)
Male (n = 55)	15 (27.3)	39 (70.9)	1 (1.8)
Age group			
24-72 months (n = 46)	12 (26.1)	33 (71.7)	1 (2.2)
72-119 months (n = 30)	13 (43.3)	16 (55.3)	1 (3.3)
≥ 120 months (n = 32)	9 (28.1)	22 (68.8)	1 (3.1)
Total (n = 108)	34 (31.5)	71 (65.7)	3 (2.8)
Heigth/age			
Type of dysfunction[1]			
Spastic (n = 79)	3 (3.8)	73 (92.4)	3 (3.8)
Others (n = 29)	4 (13.8)	23 (79.3)	2 (6.9)
Sex[2]			
Female (n = 53)	6 (11.3)	46 (86.8)	1 (1.9)
Male (n = 55)	1 (1.8)	50 (90.9)	4 (7.3)
Age group[3]			
24-71 months (n = 46)	1 (2.2)	43 (93.5)	2 (4.3)
72-119 months (n = 30)	1 (3.3)	28 (93.3)	1 (3.3)
≥ 120 months (n = 32)	5 (28.1)	25 (68.8)	2 (3.1)
Total (n = 108)	7 (6.5)	96 (88.9)	5 (4.6)

Day, 2007; BMI: Others vs. spastic [OR 20.1 (4.1, 98.4), $p < 0.001$]; children of 72-119 months vs. other two age groups, 24-71 and ≥ 120 months [OR 2.07 (0.86, 4.99), $p = 0.10$]; Day, 2007; Height/age. Fisher's exact test; [1]Type of dysfunction: Others vs. spastic [OR 4.0 (0.85, 19.3), $p = 0.08$]; [2]Sex: Female vs. male [OR 6.9 (0.8, 53.3), $p = 0.058$]; [3]Age group: ≥ 120 months vs. < 120 months [OR 6.9 (1.25, 37.4), $p = 0.023$].

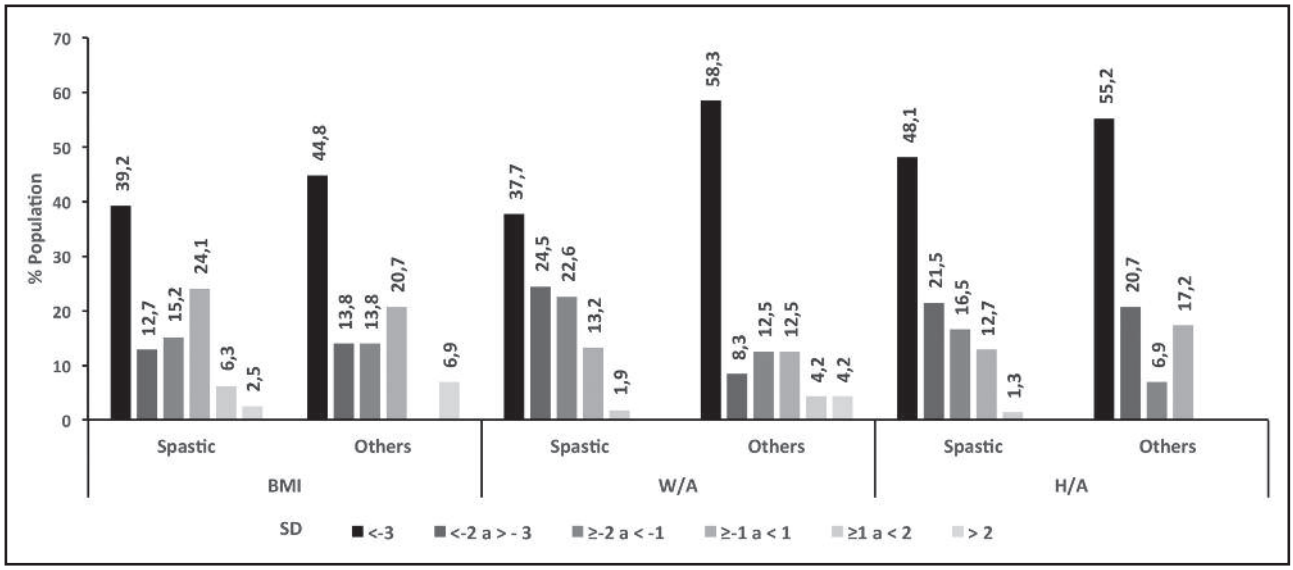

Figure 1A.

Anthropometric indexes: BMI, weight/age (W/A), and height/age (H/A) according to WHO standard references (2006, 2007).

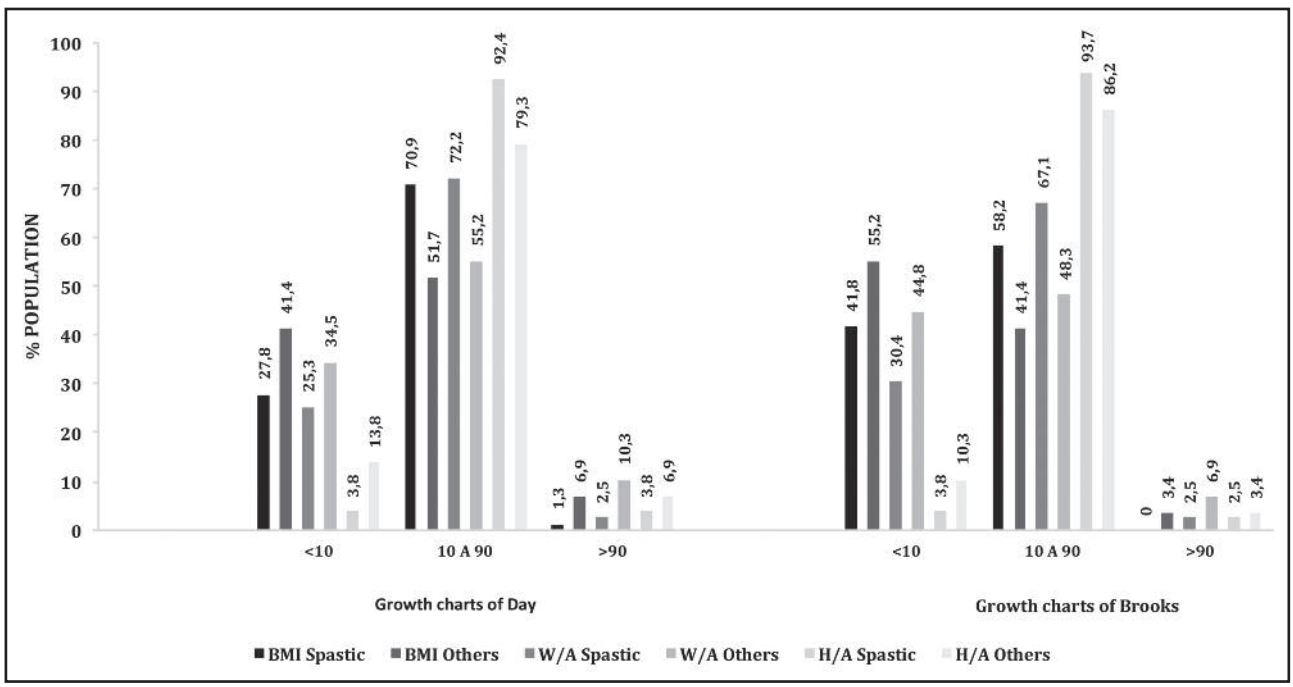

Figure 1B.

Anthropometric indexes: BMI, weight/age (W/A), and height/age (H/A) according to Day (10) and Brooks (17) growth charts Spastic group, BMI < 10 percentile, Brooks vs. Day: OR 1.86 (CI 95% 0.96, 3.6), p = 0.067. Others vs. spastic group, height/age: OR 4.0 (CI 95% 0.85, 19.3), p 0.08.

Figure 1B shows the same indexes according to Day and Brooks growth charts. When we compared the BMI between both references of the children who were below the 10th percentile and between the spastic group *vs.* others, no significant differences were observed.

DISCUSSION

To our knowledge, this is the first study in Mexico that evaluates the nutritional status of children with cerebral palsy according to the type of motor dysfunction and uses the growth charts of Day

and Brooks et al. (10,17). As observed in previous studies (20), the spastic dysfunction predominated and occurred in 79 of the 108 cases that completed the study, so the other types (ataxic n = 1, dyskinetic n = 3, hypotonic n = 11, and mixed n = 14) occurred in 29 cases. According to the Day classification, most of the children belonged to group 3, which have a severe brain dysfunction and to group 5, which comprises children with serious deterioration that forces them to remain bedridden and live with gastrostomy.

The differences in weight and height favoring children with spastic CP *versus* the other types of dysfunction were manifest. One might speculate that these differences in weight are explained by the greater lean mass in children with spastic CP due to the constant muscle spasms that characterize it. However, the height was also significantly higher in the spastic group. Perhaps the age of the spastic group (101.4 ± 78.9 months) *versus* other types of dysfunction (79.8 ± 51.6 months) had influenced these differences, p = 0.011. The growth retardation has been associated with the type of dysfunction and topographical distribution of this. Patients with more severe CP tend to weigh less and be smaller in stature than children with less severe disabilities (4,10). When anthropometric indicators among male and female children were compared, a non-significant trend toward greater weight, height, and alternative measures of height was observed in males. We supposed that this anthropometric pattern is explained by the difference between the sexes as it is in children without CP. With regard to the different age groups, it is reasonable suppose that as age advanced, most of the anthropometric indicators increased. The MUAC was lower in children 24-71 months and was similar in the 72-119 and ≥ 120 months' groups. Perhaps the reason correlates with the small increase in lean mass between schoolchildren and adolescents, which would indicate the presence of hypotrophy in both age groups. It was interesting that the TSF seemed significantly greater in the group of 72-119 months compared to the other two groups. A decrease is observed in TSF in the ≥ 120 months group compared with the 72-119 group. It is likely that the onset of adiposity that happens physiologically in healthy children between five and six years of age may have influenced this result (25).

Measuring the length and height in children with spastic CP is difficult and imprecise due to contractures, spasticity, and spinal deformities these children present; therefore, alternative measurements have been used for several years for height, using different body segments, particularly LLL, UAL, and KH (8,9,26,27). In our study, we show that the estimation of height by the measurement of LLL and KH was very similar, and both differed significantly from the height estimated by UAL as it was showed in previous studies (27). When alternative measures were separated from the type of spastic dysfunction *versus* other types of dysfunction, similar outcomes were observed.

We observed that 31.5% of the total population was below the 10th percentile on BMI with the Day growth charts. In addition, children with other types of dysfunction showed a high frequency of BMI below the 10th percentile (41.4%) compared with children of the spastic group (27.8%); this occurred particularly with the mixed-dysfunction type. It is possible that the mixed-type dysfunction is more affected by nutritional status than by increased brain damage. Schoolchildren of 72-119 months showed higher frequency of BMI below the 10th percentile. One possible explanation is that parents have more difficulties feeding and caring for this group.

Araujo and Silva (16) showed that 13% and 36% of children with CP had a BMI below the 10th percentile curves, using Brooks's charts and CDC references, respectively. However, there is controversy about using alternative measures for height to calculate BMI because they include a degree of error associated with the prediction equation, and the evaluation of BMI would magnify the error when squaring the estimated height (26).

Our data was similar to those found by Araujo and Silva (16) with respect to the height/age index but no with respect to BMI. With the growth charts of Brooks, one percent of the cases were below the 10th percentile; 90% between the 10th and 90th percentile; and 9% above the 90th percentile (16). In addition, when we were using the Day growth charts, 6.5% were below the 10th percentile; 88.9% were between the 10th and 90th percentile; and 4.6% were above the 90th percentile.

A smaller deficit was observed in the height/age index in children with spastic CP (3.8%) versus children who had other types of dysfunctions (13.8%). Even when we double the number of observations per cell of the contingency table, it is more likely that deficit will appear in the group with other dysfunctions than in the group of children with spastic CP. We have no clear explanation for this finding. A frank tendency to higher deficit in the height/age index in girls (p = 0.058) is apparent. In studies of children without CP, an increased risk of severe primary malnutrition is observed in girls over boys, especially in populations of the very low socioeconomic stratum or indigenous areas (28). This raises the possibility of potential gender discrimination in that chronic malnutrition, expressed as the deficit in the height/age index, would be more common in girls with CP.

When the indicator height for age is analyzed by age group, it shows that children older than 120 months have seven times more likely [OR = 6.8 (1.2-37.4), p = 0.023] a deficit than children 24 to 120 months. This finding could be explained by considering that by the time the child with CP becomes older, he or she would have endured a longer period of food insufficiency, which consequently would have adversely affected his or her growth.

The results obtained with anthropometric data confirm that the gold standard of WHO (23,24) is not suitable for the anthropometric evaluation of children with CP. As observed, the indexes of weight/age, height/age, and BMI of the majority of the children studied were between -3 and -2 standard deviations regardless of the type of dysfunction, sex, and age group. In recent years, studies have been conducted to define the most appropriate methods and reference patterns to assess the growth and development of children with CP (16). Although several growth charts for this population have been published, there is debate about the use of such charts because they are not recommended by the CDC (26). Using the same growth charts for children with neurological impairment as for the population of healthy children is questionable because it tends to overestimate malnutrition and growth and development

in children with CP, which is different from the growth and development of children without this condition (8,16,17). In addition, Day et al. (10) reported that the measurement of height of children with CP at groups 3 y 5 is more difficult; therefore, the estimated final height should be accepted with caution.

Further studies are needed, an important step would be to identify direct markers of malnutrition supported by clinical, bio physical and laboratorial data, which are clearly more frequent among those children below the 10th percentile (or whatever percentile used to define malnutrition), so we could have real clinical evidence of malnutrition, not only by anthropometric assessment.

CONCLUSION

Our study showed that the nutritional status of children with CP differs, depending on the sex, age, and type of motor dysfunction, and can be adequately evaluated through alternative measures of the height such as knee height and lower-leg length. We consider the Day et al. (10) and Brooks et al. growth charts (17) are useful for evaluating nutritional status of the specific population. The most affected age groups in the index height/age and BMI were schoolchildren 72-119 months of age and the adolescent group of ≥ 120 months old, with a higher proportion of girls more affected than boys. In spite of the difficulties and controversies that persist, more studies and anthropometric growth charts are necessary for proper estimation of different anthropometric indicators, especially for height, for their use in clinical practice and investigative settings.

ACKNOWLEDGMENTS

We would like to thank to Dr. Juan Hernandez Rocha, pediatric neurologist, the staff at the Hospital Civil of Guadalajara "Dr. Juan I Menchaca," nutritionists Silvia Monserrat Rodríguez León and Elvira Monserrat Uribe Martinez, and the staff of the Infant Nutrition Unit at the same hospital.

REFERENCES

1. Del Águila A, Aibar P. Características nutricionales de niños con parálisis cerebral. ARIE - Villa El Salvador. An Fac Med Lima 2006;67:108-19.
2. Lorente Hurtado I. La parálisis cerebral. Actualización del concepto, diagnóstico y tratamiento. Pediatr Integral 2007;XI:687-98.
3. Rieken R, Calis EAC, Tibboel D, Evenhuis HM, Penning C. Validation of skinfold measurements and bioelectrical impedance analysis in children with severe cerebral palsy: A review. Clinical Nutrition 2010;29:217-21.
4. Shapiro BK, Green P, Krick J, Allen D, Capute AJ. Growth of severely impaired children. Neurological versus nutritional factors. Dev Med Child Neurol 1986;28:729-33.
5. Marchand V, Motil K. Nutrition support for neurologically impaired children: a clinical report of the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. J Pediatr Gastroenterol Nutr 2006;43:123-35.
6. Hurvitz EA, Green LB, Hornyak JE, Khurana SR, Koch LG. Body mass index measures in children with cerebral palsy related to gross motor function classification: a clinic-based study. Am J Phys Med Rehabil 2008;87:395-403.
7. Moreno Villares JM, Galiano Segovia MJ, Valero Zanuy MA, León Sanz M. Alimentación en el paciente con parálisis cerebral. Acta Pediatr Esp 2001;59:17-25.
8. Stevenson RD, Conaway M, Chumlea WC, Rosenbaum P, Fung EB, Henderson RC, et al. Growth and health in children with moderate-to-severe cerebral palsy. Pediatrics 2006;118:1010.
9. Stevenson RD. Use of Segmental measures to estimate stature in children with cerebral palsy. Arch Pediatr Adolesc Med 1995;149:658-62.
10. Day SM, Strauss DJ, Vachon PJ, Rosenbloom L, Shavelle RM, Wu YW. Growth Patterns in a population of children and adolescents with cerebral palsy. Dev Med Child Neurol 2007;49:167-71.
11. Krick J, Murphy-Miller P, Zeger S, Wright E. Pattern of growth in children with cerebral palsy. J Am Diet Assoc 1996;96:680-5.
12. Garcia-Contreras AA, Vasquez-Garibay EM, Romero-Velarde E, Ibarra-Gutiérrez AI, Troyo-Sanromán R. Energy expenditure in children with cerebral palsy and moderate/severe malnutrition during nutritional recovery. Nutr Hosp 2015;31:2062-9.
13. Walker JL, Bell KL, Boyd RN, Davies PSW. Energy requirements in preschool-age children with cerebral palsy. Am J Clin Nutr 2012;96:1309-15.
14. Gurka MJ, Kuperminc MN, Busby MG, Bennis JA, Grossberg RI, Houlihan CM, et al. Assessment and correction of skinfold thickness equations in estimating body fat in children with cerebral palsy. Dev Med Child Neurol 2010;52:e35-e41.
15. Campanozzi A, Capano G, Miele E, Romano A, Scuccimarra G, Del Giudice E, et al. Impact of malnutrition on gastrointestinal disorders and gross motor abilities in children with cerebral palsy. Brain Dev 2007;29:25-9.
16. Araujo LA, Silva LR. Anthropometric assessment of patients with cerebral palsy: which curves are more appropriate? J Pediatr (Rio J) 2013;89:307-14.
17. Brooks J, Day S, Shavelle R, Strauss D. Low weight, morbidity, and mortality in children with cerebral palsy: New clinical growth charts. Pediatrics 2011;128:e299.
18. Spender QW, Cronk CE, Charney EB, Stallings VA. Assessment of linear growth of children with cerebral palsy: use of alternative measures to height or length. Dev Med Child Neurol 1989;31:206-14.
19. Kuperminc MN, Gurka MJ, Bennis JA, Busby MG, Grossberg RI, Henderson RC, et al. Anthropometric measures: poor predictors of body fat in children with moderate to severe cerebral palsy. Dev Med Child Neurol 2010;52:824-30.
20. Vega-Sanchez R, Gómez Aguilar M, Haua K, Rozada G. Weigth-based nutritional diagnosis of Mexican children and adolescents with neuromotor disabilities. BMC Research Notes 2012;5:218.
21. Azcue MP, Zello GA, Levy LD, Pencharz PB. Energy expenditure and body composition in children with spastic quadriplegic cerebral palsy. J Pediatr 1996;129:870-6.
22. Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol 1997;39:214-23.
23. Patrones de crecimiento infantil. Patrones de crecimiento infantil de la OMS, 2006. Retrieved January 9th 2016. Available on: http://www.who.int/childgrowth/es/
24. Growth reference data for 5-19 years. WHO reference 2007. Retrieved January 8th 2016. Available on: http://www.who.int/growthref/en/
25. Koyama S, Ichikawa G, Kojima M, Shimura N, Sairenchi T, Arisaka O. Adiposity rebound and the development of metabolic syndrome. Pediatrics 2014;133:e114-e119.
26. Samson-Fang L, Bell KL. Assessment of growth and nutrition in children with cerebral palsy. Eur J Clin Nutr 2013;67:S5-S8.
27. Garcia-Contreras AA, Vasquez-Garibay EM, Romero-Velarde E, Troyo- Sanroman R, Sandoval-Montes IM, Illescas Zarate D. Height and body mass index estimated by alternative measures in children with spastic quadriplegic cerebral palsy and moderate/severe malnutrition. Brit J Med & Med Res 2016;14(12):1-10.
28. Vásquez-Garibay E. Trato diferencial por género en relación con la nutrición y atención de la salud de la niña lactante y preescolar. Bol Med Hosp Infant Mex 2000;57:176-82.