Nutrición Hospitalaria

Original

Comparison of NCHS, CDC and WHO growth charts in the nutritional assessment of hospitalized children up to five years old

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Abstract

Aims: This study evaluated the agreement of growth charts proposed by the National Center for Health Statistics (NCHS/1977), Centers for Disease Control and Prevention (CDC/2000) and World Health Organization (WHO/2006).

Methods: Were assessed children between 0 and 5 years old, hospitalized in the pediatric wards of a Brazilian school hospital. Z-score indexes: stature/age (S/A), weight/age (W/A) and weight/stature (W/S) was evaluated, in each of the three references (NCHS, CDC and WHO). ANOVA and test Bland & Altman and Lin plots were used in the comparison of the 3 charts. The agreement of the nutritional state categories was also evaluated, through kappa coefficient. The study was approved by the Institution's Research Ethics Committee.

Results: The study analyzed 337 children, whose median age was 0.52 (IQR: 0.21-1.65) years, 65.3% of them were below 1 year old, 60.2% were male and 50% hospitalized due to acute respiratory disease. Lower Z-scores of W/A and S/A were obtained with the WHO charts and lower W/S with the CDC chart. High correlation and agreement were observed among the criteria, but more patients were classified as presenting shortness through the WHO criteria. CDC and WHO criteria were more rigorous than the NCHS criteria for the diagnosis of underweight (W/A) and malnutrition (W/S).

Conclusion: Despite the strong agreement of the 3 charts, the adoption of the WHO charts seems to be more helpful for the children's nutritional screening for admission, as it enables to detect a higher number of malnourished children or at nutritional risk, who will benefit from an early intervention.

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Key words: *Children's growth. Growth charts. Hospitalized child. Malnutrition. Hospital.*

COMPARACIÓN DE LAS CURVAS DE CRECIMIENTO DEL NCHS, CDC Y LA OMS EN LA VALORACIÓN NUTRICIONAL DE LOS NIÑOS HASTA CINCO AÑOS HOSPITALIZADOS

Resumen

Objetivo: Este estudio comparó las curvas de crecimiento para la clasificación de la puntuación Z de talla/edad (T/E), peso/edad (P/E) y peso/talla (P/T) propuesto por el Centro Nacional para Estadísticas Sanitarias (NCHS, 1977), *Centers for Disease Control and Prevention* (CDC/2000) y la Organización Mundial de la Salud (OMS/2006).

Métodos: Niños entre 0 y 5 años de edad hospitalizados en las salas de pediatría de un hospital terciario en Brazil fueron valorados. Se utilizaron ANOVA, Bland & Altman y gráfico de Lin en la comparación de las 3 curvas de crecimiento. Las categorías del estado nutricional se evaluaron por coeficiente kappa. El estudio fue aprobado por el Comité de Ética de la institución.

Resultados: El estudio analizó 337 niños, cuya edad fue 0,52 (IQ: 0,21-1,65) años, 65,3% de ellos eran menores de 1 año de edad, 60,2% eran varones y 50% con enfermedades respiratorias agudas. Se obtuvieron puntuaciones Z más bajas de P/E y T/E con la curva de la OMS y más bajo P/T con la tabla del CDC. Fue observada fuerte concordancia entre los 3 criterios, pero más pacientes se clasificaron como "baja estatura" por los criterios de la OMS. Los criterios del CDC y OMS eran más rigurosos que las del NCHS para el diagnóstico de la insuficiencia ponderal (P/E) y la malnutrición (P/T).

Conclusión: A pesar de la fuerte concordancia de las 3 curvas, la adopción de los criterios de la OMS parece ser más útil para el diagnóstico nutricional de los niños al ingreso hospitalario. Con esto se hace posible detectar un mayor número de desnutridos o en riesgo nutricional que se beneficiarán de la intervención temprana.

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Palabras clave: *Crecimiento de los niños. Curvas de crecimiento. Niños hospitalizados. Desnutrición. Hospital.*

Introduction

The systematic assessment of nutritional state is an important procedure for the global health, recommended by the World Health Organization (WHO), the Brazilian Department of Health and the Brazilian Society of Pediatrics.[1] This assessment can explain present and past occurrences and indicate probabilities of future risks to the child's health. For this purpose, growth charts are adopted, which relate values of weight, stature and age adjusted by gender, and where the percentiles or Z-score expected for the age are used in comparisons.

Today, three growth charts are available for the health professionals to monitor the nutritional state of children from 0 to 5 years of age: a) National Center for Health Statistics (NCHS/1977),[2] b) Centers for Disease Control and Prevention (CDC/2000)[3] and c) WHO/2006.[4] For the development and validation of each of these instruments, studies were conducted in several populations, which could explain the differences found when assessing the same child through the three charts.

In the NCHS/1977 charts, all age groups and social classes were included in the group between 2 and 18 years old, but only white individuals of middle class were included in the age group between 0 and 36 months old. For the elaboration of the CDC/2000 charts, American individuals of ethnic diversity, between 0 to 20 years old, were included, upper and lower stature limits were extended, improvements in the statistical tests were made and new percentiles were presented to the 16 charts available. The instruments proposed in 2006 by the WHO, for children from 0 to 5 years old from different ethnic groups (data collected in several countries), were based on what is considered as "ideal" growth of these individuals, without economic, environmental, nutritional or genetic limitations to their development.

The children's nutritional state classification, regardless of the instrument employed, considers the percentile or Z-score to each evaluated index: stature/age (S/A), weight/age (W/A) and weight/stature (W/S).

Although developed and validated in the context of individuals not submitted to chronic and/or acute disorders, these instruments are widely used in nutritional assessment routines of hospitalized children, where the cutoff points of Z-score for risk and malnutrition could be others, given the presence of new variables.

The purpose of this study was to compare the agreement of NCHS, CDC and WHO growth charts regarding the nutritional state classification of children between 0 and 5 years old hospitalized in a general hospital of high complexity in southern Brazil.

Patients and methods

This study is part of a more comprehensive study that assessed the alterations in the nutritional state of 426 hospitalized children[5] and was approved by the Research Ethics Committee of our Institution regarding its ethical and methodological aspects. So, this study evaluated 337 patients between 0 and 5 years of age, hospitalized between March and October 2004 in the pediatrics wards. Each patient was included only once, no matter a new hospitalization occurred in other occasions during the study period. Not included children from oncology and intensive care units, children with Down Syndrome, without clinical conditions for weight and/or stature measurement, such as those wearing cast immobilization, with muscular spasticity, bone deformity and those without a formal consent. The study was preceded by training to the research assistants on the invitation, study participation and consent obtention, proper technique of weight and stature measurements and study form filling.

This is an observational study. During the study period, no alterations were made to the routine services provided by the teams. The same study protocol was adopted for all patients; they were all evaluated in the first 48 hours of hospitalization. The patients were submitted to weight and stature measurements, always performed by two researchers, regardless of recent registrations of these data in the child's clinical records.

The body weight was measured using previously calibrated digital scales from the hospitalization division. Children up to two years old or up to 15 kg were weighted completely undressed; they were placed laying or sitting in the middle of the scale, without any external support. Taller children were weighted in light clothes or sitting in the middle of the scale, without any external support. For length measurement, children up to 2 years old were placed laying on a flat place, and a ruler with a fixed support at one end for the head positioning and a retractable support at the other end for feet positioning (procedure performed by two investigators to ensure stretched body and correct positioning). The stature was measured with an anthropometer, where the child was placed barefoot, with ankles together in contact with the vertical rod of the anthropometer, head in erect position, and the horizontal cursor of the anthropometer retracted to the highest point of the child's head.

Z-score values for indexes S/A, W/A and W/S were obtained for each child, in each of the three references

(NCHS/1997, CDC/2000 and WHO/2006). For the calculations, the following applications were used EPI INFO version 3.4.3 (NCHS/1997 and CDC/2000) and ANTHRO/2006 (OMS/2006). The nutritional state was classified as: (a) malnutrition due to underweight when Z-score ≤ -2 SD for indexes W/A and W/S, (b) shortness when Z-score ≤ -2 SD for S/A, (c) risk for underweight when Z-score between -1.99 SD and -1.28 SD for W/S and W/A, (d) normal when Z-score between -1.27 SD and +1.27 SD for W/S and W/A, and >-1.99 SD for S/A, (e) risk for overweight when Z-score between +1.28 SD and +1.99 SD for W/S or W/A and (f) overweight and obesity when Z-score ≥+2.00 SD for W/S and W/A.[6-8] For premature patients below 2 years old, the chronological age was corrected with the gestational age.[9]

The comparison of the three charts of NCHS, CDC and WHO for each of the indexes (W/A, S/A and W/S) was made using ANOVA test for repeated measurements, with the Bonferroni correction. The agreement of charts was assessed by Bland & Altman[10] and Lin[11] plots for continuous variables. For the comparison of categorical variables, McNemar's test was made and *kappa* coefficient was calculated. The analyses were performed in the application Statistical Package for the Social Sciences (SPSS), version 16.0, and the P-values < 0.05 (2-tailed) were considered statistically significant.

Results

The study assessed 337 children, whose age median was 0.52 (IQR: 0.21-1.65) years, 65.3% of them were below 1 year old, 60.2% were male and 50% hospitalized due to acute respiratory disease. Differences were identified when comparing the mean values of Z-score from the NCHS, CDC and WHO charts for indexes: W/A ($p < 0.001$), S/A ($p < 0.001$) and W/S ($p = 0.004$). Lower mean values of W/A and S/A were obtained when adopting the WHO charts, while a lower mean value of W/S was observed when adopting the CDC chart (Fig. 1). That was confirmed with the assessment of patients sorted into categories according to their nutritional state, through the different indexes.

Despite the high agreement among the three criteria, when using the WHO chart, more patients were classified as presenting shortness than when adopting the criteria of NCHS ($p < 0.001$) and CDC ($p < 0.001$) (Table I). In the W/A comparison, the criteria of CDC ($p < 0.001$) and WHO ($P = 0.018$) were more rigorous in the classification of underweight and risk for underweight than the criteria of NCHS (Table II). For W/S, the criteria of CDC ($p < 0.001$) and WHO ($p < 0.001$) were also more stringent than those of NCHS, with CDC still more than WHO ($p = 0.003$) (Table II).

Figure 2 shows the differences resulting from the comparison of the diagnostic criteria (NCHS, CDC and WHO) for the indexes: W/A (Fig. 2a-2c); S/A (Fig. 2d-2f) and W/S (Fig. 2g-2i), indicating that, despite the strong agreement among these criteria, WHO and CDC
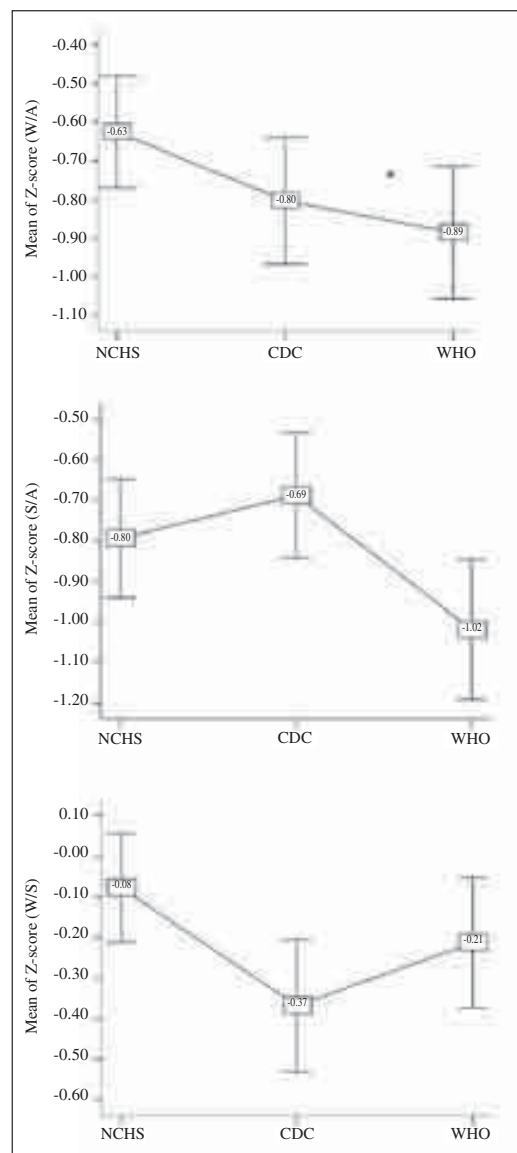

Fig. 1.—*ANOVA for repeated measurements, comparing the mean values of the different charts. Bonferroni correction p < 0.001 for all comparisons, except for W/A between CDC and WHO (*p = 0.014).*

tend to be more rigorous than NCHS. Likewise, Figure 3 shows the strong correlation of the criteria, emphasizing again that WHO and CDC classify the patients for worse nutritional state.

Discussion

According to NCHS/1977, CDC/2000 and WHO/ 2006 criteria, an agreement was observed when com-

Table I
Agreement of classification criteria NCHS/1977, CDC/2000 and WHO/2006 for S/A in children of ≤ 5 years of age, considering shortness of patients presenting Z-score ≤ 2.0 SD. Data presented in absolute numbers (n = 337)

	shortness	not shortness	p	kappa
CDC				
NCHS				
shortness	45	8	0.388	0.861*
not shortness	4	280		
WHO				
NCHS				
shortness	53	0	< 0.001	0.781*
not shortness	23	261		
WHO				
CDC				
shortness	49	0	< 0.001	0.738*
not shortness	27	261		

*P < 0.001;NCHS: National Center Health Statistics; CDC: Centers for Disease Control and Prevention; WHO: World Health Organization.

Table II
Agreement of classification criteria NCHS/1977, CDC/2000 and WHO/2006 for W/A and W/S in children of ≤ 5 years of age. Data presented in absolute numbers (n = 337)

		W/A							W/S					
		UW	UW risk	Normal	OW risk	OW/ obese	p	Kappa	UW	UW risk	Normal	OW risk	OW/ obese	p	Kappa
CDC															
NCHS	UW	**48**	0	0	0	0			**18**	0	1	0	0		
	UW risk	13	**43**	3	0	0			15	**12**	1	0	0		
	normal	0	17	**185**	3	0	< 0.001	0.797*	5	29	**205**	4	0	< 0.001	0.627*
	OW risk	0	0	1	**13**	1			0	0	3	**20**	0		
	OW/obese	0	0	0	3	**7**			0	0	0	2	**13**		
WHO															
NCHS	UW	**46**	6	0	0	0			**16**	3	0	0	0		
	UW risk	20	**24**	15	0	0			12	**11**	5	0	0		
	normal	4	24	**173**	4	0	0.018	0.606*	7	25	**202**	9	0	< 0.001	0.620*
	OW risk	0	0	4	**10**	1			0	0	1	**21**	1		
	OW/obese	0	0	0	1	**9**			0	0	0	0	**15**		
WHO															
CDC	UW	**50**	11	0	0	0			**29**	9	0	0	0		
	UW risk	15	**28**	17	0	0			3	**27**	11	0	0		
	normal	1	15	**168**	5	0	0.740	0.627	3	5	**200**	7	0	0.003	0.784*
	OW risk	0	0	7	**8**	4			0	0	0	**24**	3		
	OW/obese	0	0	0	2	**6**			0	0	0	0	**16**		

W/A: weight-for-age index; W/S: weight-for-stature index; CDC:Centers for Disease Control and Prevention;UW: underweight ; UW underweight risk; OW risk: overweight risk; OW: overweight; NCHS: National Center Health Statistics; WHO: World Health Organization;*: P < 0001.

paring indexes S/A, W/A and W/S, in the classification of hospitalized patients between 0 and 5 years old. Yet, small differences were observed in the mean values of Z-score. Lower values of Z-score, for S/A and W/A, were obtained with the WHO charts, classifying more patients in the categories of shortness and underweight, suggesting that it is a more useful criterion to screen malnutrition and nutritional risk for hospital admission.

The literature has few references comparing the performance of charts in hospitalized children, especially in Brazilian hospitals. However, studies with different populations of non-hospitalized children obtained sim-
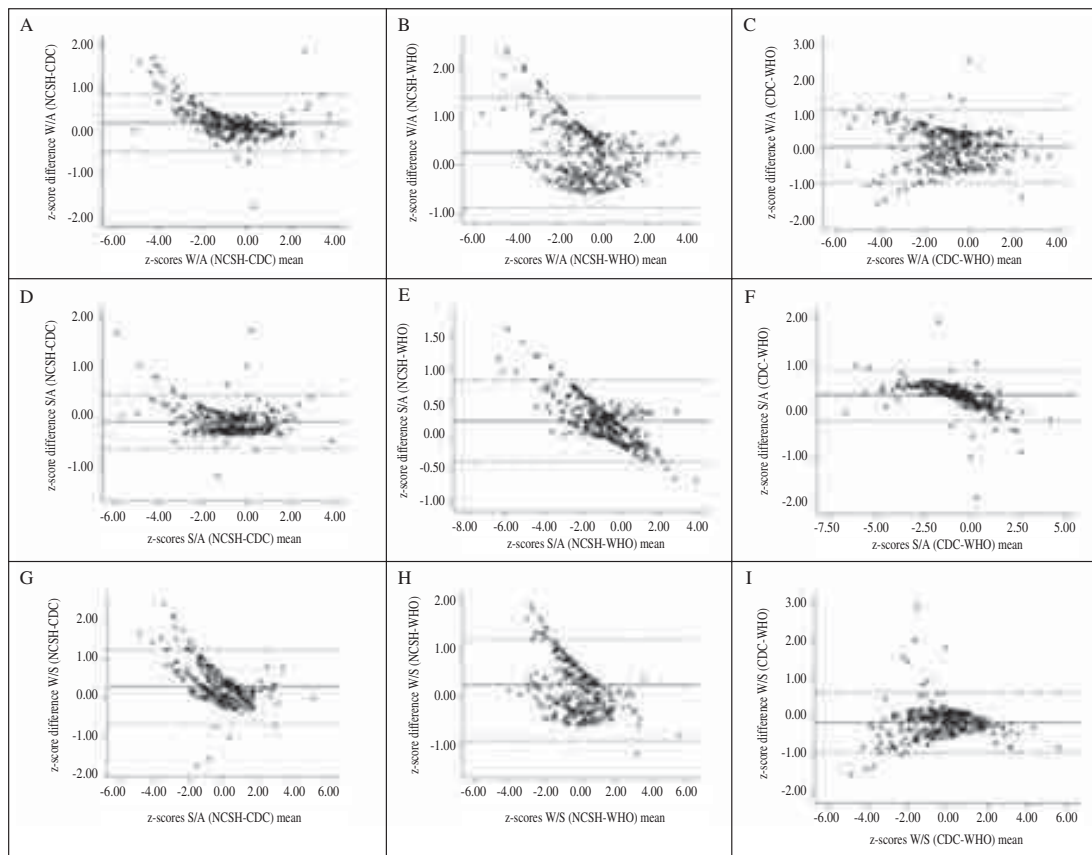
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Fig. 2.—Differences of Z-score for weight/age (A to C), stature/age (D to F) and weight/stature (G to I) through NCHS (A, D, G), CDC (B, E, H) and WHO (C, F, I) charts, along the mean of values obtained with the charts assessed (axis x). The continuous lines show the difference mean and the broken lines show ± 1.96 standard deviation of the difference mean (Bland & Altman plot).

ilar data to those found in this study. Torres et al[12] showed similar data to ours when evaluating impaired growth in preschool non-hospitalized children using the CDC 2000 and WHO 2006 criteria. They observed more weight reduction (W/S) and stature reduction (S/A) when using the WHO criteria, although these differences were not significant in the statistical perspective in any group age. On the other hand, in the Multicentre Growth Reference Study (MGRS) elaborated by the WHO,[13] non-hospitalized children had the diagnosis of nutritional impairment earlier when using the WHO standard.

In a posterior study, Onis et al.[14] compared the WHO and NCHS growth charts and found higher malnutrition in W/A in the first six months of life, when based on the WHO standard. The prevalence of 2.5 times higher when compared to the criteria of NCHS. The same was observed in S/A, the prevalence of stunting was higher in all ages when the WHO standard was adopted. For W/S, during the first six months of life, the prevalence of wasting and severe wasting using the WHO standard was, respectively, 2.5 and 3.5 times

those estimated using the NCHS reference. Likewise, when comparing the CDC and WHO charts, the WHO group[15] found higher malnutrition when the WHO criteria were adopted. Such data agree with the results of this study, emphasizing that the age median of the sample for this study was around 6 months old.

Almeida et al.[16] evaluated 841 Brazilian non-hospitalized children of max. five years old through four methods. Just like us, the authors showed agreement when comparing the methods, confirming that, in large groups of children dispersed in the population presenting several degrees of malnutrition, different methods are highly correlated. Yet, caution should be considered in individual assessment, as different methods can reproduce different scores to the same child.

With the purpose of studying shortness and underweight, Schwartz et al.[17] conducted a study with a cohort of 289 African children up to the 15th month after their birth, using the WHO, CDC and NCHS growth charts. The highest incidence of underweight at the 3rd month of age was identified with the adoption of the WHO charts in relation to CDC (4% *vs.*
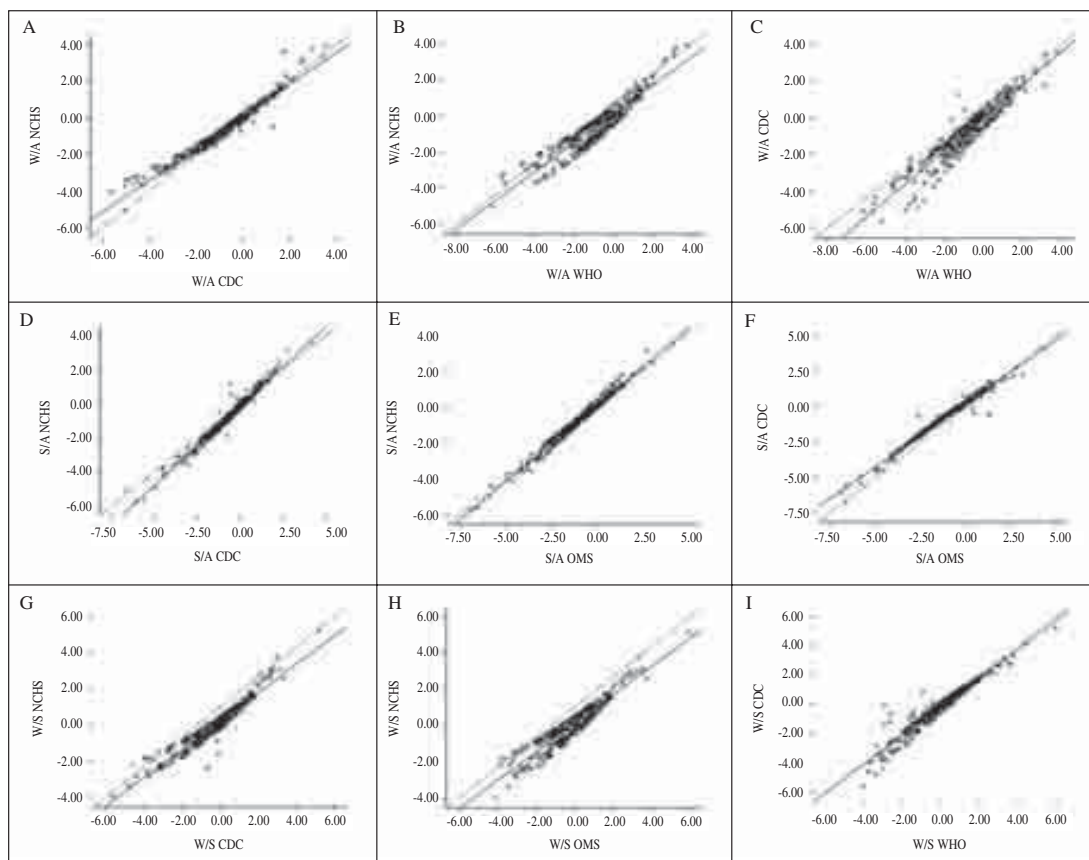
Fig. 3.—*Differences of Z-score for weight/age (A to C), stature/age (D to F) and weight/stature (G to I). The broken lines show what would be the perfect agreement of the methods (angle of 45° of axis Y and X), while the continuous lines indicate the straight line estimated for the agreement found in this study. Each point represents the same patient, assessed through the different criteria.*

1%) and to NCHS (4% *vs*. 0.7%). Similar differences were identified in the evaluations made at the 9th and 15th month of life. Just like in our study, the diagnosis of shortness through the WHO charts was more sensitive in all evaluations.

Mei et al.[18] assessed weight and stature of children between 0 and 59 months of age (n = 3,920) included in the National Health and Nutrition Examination Survey 1999-2004, unifying the cutoff point of the CDC and WHO charts. The authors found more shortness with the WHO charts.

Malnutrition is a frequent comorbidity at the moment of hospitalization; it can affect one out of 5 children of our context. The early detection of this event can enable a different nutritional attention. In this sense, as a measurement of nutritional screening, despite the strong agreement of the NCHS, CDC and WHO charts, the adoption of the WHO charts seems to be more useful to detect the highest possible number of malnourished children or children at nutritional risk, who should receive early nutritional interference already at the admission.

Conclusion

Despite the strong agreement of the 3 charts, the adoption of the WHO charts seems to be more helpful for the children's nutritional screening for hospital admission, as it enables to detect a higher number of malnourished children or at nutritional risk, who will benefit from an early intervention.

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