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The Low Prevalence of Weight-for-Height Deficits in Brazilian Children Is Related to Body Proportions[1]

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ABSTRACT Compared with children from other regions, Latin American children living in poverty have much lower prevalences of weight-for-height deficits than would be expected given the observed rates of stunting. This study was aimed at investigating whether variations in body proportions, particularly abdominal circumference, could explain this paradoxical finding. In a cross-sectional study, children aged 12–35 mo ($n = 197$) were studied in Southern Brazil. Half of these children were from a high socioeconomic status (SES) group whose growth closely resembled that of the National Center for Health Statistics (NCHS)/WHO reference; the other half were from low income families. The following 11 anthropometric measurements were collected: weight, height, sitting height/crown-rump length, head, chest, upper arm and abdominal circumference, triceps, biceps, subscapular and suprailiac skinfolds. These measures were compared between the two groups of children and with values for North American children [mostly from Second National Health and Nutrition Examination Survey (NHANES II)]. For nearly all measures, low SES Brazilian children tended to be smaller than both high SES and North American children. However, when body proportionality was assessed by dividing the measurements by the child's height, these differences tended to disappear or even to change direction, as was the case for head, chest and abdominal circumferences. Mean abdominal circumference was virtually identical between low and high SES children, and the former had larger abdomens for a given height. Despite slight differences in measuring techniques, Brazilian children had larger abdomens than North Americans. These findings may explain in part why deprived Latin American children have higher weights for their height compared with the NCHS/WHO reference. J. Nutr. 131: 1290–1296, 2001.

KEY WORDS: • *humans* • *anthropometry* • *wasting* • *abdominal circumference* • *preschool children*

Height for age and weight for height are widely used for assessing the nutritional status of populations (WHO 1986 and 1995). The worldwide distribution of low height for age (stunting) and low weight for height (traditionally referred to as wasting) suggests that these indicators have somewhat different etiologies (Golden 1995, Keller 1988, Victora 1992, Waterlow 1996). In particular, several studies from Latin America have shown low prevalences of weight-for-height deficits, usually between 2 and 5%, regardless of the prevalence of stunting. A prevalence of low height for age (stunting) of 35% was associated with mean prevalences of low weight for height of ~4% in Latin America; for the rest of the world, however, these ranged from 9% in the Eastern Mediterranean to 15% in Asia (Victora 1992). This paper investigates some possible explanations for this paradox.

Golden (1995) suggested that poor physical growth is due to deficits in one or more type II nutrients (potassium, sodium, magnesium, zinc, phosphorus, protein, oxygen, water and also energy). Stunting or wasting would result from the intensity and duration of exposure to these deficits, as well as from specific nutrient deficiencies or their combination. Mild, long-acting deficits would lead to stunting, whereas wasting is usually associated with short-term, intense deficits (Golden 1995); this is in agreement with the higher prevalences of stunting than of low weight for height (wasting) observed in epidemiologic studies (WHO 1995). What seems to be peculiar about Latin America is that prevalences of low weight for height are much lower than would be expected given the observed stunting rates.

Wasting has been traditionally measured through weight for height (WHO 1995). Low weight for height has thus been interpreted as a condition in which body fat and muscle are reduced, that is, the child is wasted (Golden 1995, Waterlow 1996, WHO 1995). However, if a child is truly wasted but there is also a relative increase in other body proportions such as visceral volume or bone structure, the child may still have a normal weight for height. Therefore, another possible explanation for the wide discrepancy between weight-for-height deficits and stunting rates in Latin America is that the body proportions of these children may differ from those of North American children on whom the National Center for Health

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Statistics (NCHS)[3]/WHO reference is based. In particular, malnourished children often present large abdomens (Jelliffe 1968, Pessôa and Martins 1974, Quarentei 1976). This finding has been attributed to weak muscular tone of the abdominal wall (therefore allowing viscerae to protrude) or to a high intestinal helminth load (Quarentei 1976). A large abdomen would be expected to increase the child's weight without affecting height.

A study of Peruvian children showed that, compared with the NCHS/WHO reference (Boutton et al. 1987, Trowbridge et al. 1987), the children presented a slight increase in total body water and a reduction in muscle and fat. Peruvian children also had greater crown-rump lengths than North American children of the same height. These differences, according to the authors, could partially but not fully explain the greater weight for height in Peruvian children (Trowbridge et al. 1987). Abdominal circumference was not addressed in that study.

Cesar et al. (1996) showed that the abdominal circumferences of children <5 y old from Northeast Brazil were on average 3–5 cm greater than North American children, but measurement techniques were somewhat different. According to these data, abdominal circumference explained 16% in the variability of weight for height, after allowing for upper arm circumference and for age.

Another recent study from Southern Brazil addressed this issue in a low socioeconomic status population by taking 13 different measures in each child (Post et al. 1999 and 2000). Stunted children aged 6–59 mo had greater abdominal, head and chest circumferences relative to their height than nonstunted children, but had lower skinfold thickness indices (Post et al. 2000). Stunted children also had abdominal circumferences that were 1.0 cm greater than those from North America, but again measurement techniques differed. A multiple linear regression analysis including several anthropometric measurements showed that abdominal circumference was the second variable most strongly correlated to weight for height (upper arm circumference was the first) (Post et al. 2000). After adjusting for other anthropometric measurements, each 1-cm increase in abdominal circumference would be expected to increase weight for height by 0.12 Z-score.

These studies suggest that children with larger abdomens, chests or heads will be heavier, and this may explain in part why low weight for height may be uncommon. Their samples were restricted to children from low socioeconomic status (SES) families, who represent most of the Brazilian population. Ideally, one would like to compare their abdominal circumference and other body proportions with the North American children from whom the NCHS/WHO reference was derived, using the same measurement protocols, but comparable data are not available. Because high SES children in Brazil show weight and height growth patterns that are very similar to the NCHS/WHO reference, they provided a control group whose body measures could be compared with the low SES children, to confirm that the observed differences in abdominal, head and chest circumference were not due to measurement bias. In the present investigation, several anthropometric indices were compared in these two groups of children to test the hypothesis that differences in body proportions, particularly abdominal circumference, may explain, at least in part, the low prevalences of low weight for height in Latin American children.

SUBJECTS AND METHODS

The sample included 197 children aged 12–35.9 mo from two groups with contrasting SES living in the city of Pelotas in southern Brazil in 1995. The low SES group included 96 children resident in the Getúlio Vargas slum area of Pelotas; the high SES group was sampled from the city center. Both groups of children were selected using the same methodology. On the basis of a birth cohort study conducted in 1993 (Barros and Victora 1996), a starting point was randomly chosen; all households were visited consecutively according to a predefined sequence until 95 children were located (the actual sample sizes were slightly higher because some children who were temporarily out of town during the initial field work phase and who returned later were measured after the quota had been completed). In the central area of the city, only children from families earning ≥US$120/mo were included (earlier research in the same city showed that prevalences of anthropometric deficits in this subpopulation were similar to those in the NCHS/WHO reference) (Post et al. 1996). There were no refusals in the slum, but 8 families (7.9%) from the city center refused to participate. All interviewers measured similar numbers of children in each SES area.

Sample sizes (Kirkwood 1988) were calculated to detect significant differences in anthropometric measurements that had been found in the earlier study (Post et al. 1999) comparing stunted and nonstunted children. Standard deviations from this earlier study were used in the calculations. With 95 children in each group, the study had a power of ≥85% of detecting the following differences: 800 g for weight, 2.5 cm for height, 1.3 cm for sitting height or crown-rump length, 1.4 cm for subischial height, 0.8 cm for head circumference, 1.3 cm for chest circumference, 0.5 cm for upper arm circumference, 1.5 cm for abdominal circumference, 0.7 mm for triceps skinfold, 0.5 mm for biceps skinfold, 0.7 mm for subscapular skinfold, 0.9 mm for suprailiac skinfold, 1.2 cm^2 for total upper arm area, 0.8 cm^2 for upper arm muscle area and 0.6 cm^2 for upper arm fat area. The sample size was sufficient for detecting even relatively small differences for all but the skinfold measurements; because of their large SD observed in the earlier study, these measurements required much larger sample numbers.

A pretested, standardized questionnaire was used to collect information on demographic, socioeconomic and environmental variables, birthweight and child morbidity. Presence of a flush toilet was used as the environmental sanitation indicator because virtually all families have access to piped water and there would be little variability in the sample. The morbidity indicators included reported diarrhea in the 2 wk before the interview and hospital admissions in the previous 12 mo. Hospitalizations are a good indicator of severe morbidity because there are a large number of hospital beds in the city and there are no economic barriers to health care due to universal health insurance.

Anthropometric measurements included the following: weight, measured with portable CMS-PBW weighing scales (CMS Weighing Equipment, London, UK, precision: 100 g); height (for children aged 24–35 mo) or length (for children aged 12–23 mo) and sitting height (or crown-rump length) measured using locally constructed boards according to WHO specifications (National Household Survey Capability Program 1986; precision: 1 mm); triceps, biceps, subscapular and suprailiac skinfolds, measured with John Bull (London, UK; precision: 0.2 mm) and Cescorf (Porto Alegre, Brazil; precision: 0.1 mm) calipers; head, upper arm, chest and abdominal circumferences, measured with 7-mm wide Lufkin Y613CMD nonstretchable tape (Paris, France; precision: 0.1 cm).

From the measurements, the following indices were calculated: fat, muscle and total upper arm areas (Frisancho 1990); proportion of sitting height over total height (or crown-rump length over total length) and subischial height over total height (or subischial length over total length) (Lohman et al. 1988). Maternal height was measured with a locally manufactured anthropometer, and upper arm circumference with the same tapes used for the children. All anthropometric techniques were standardized (Cameron 1984, Lohman et

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[3] Abbreviations used: DHHS, Department of Health and Human Services; NCHS, National Center for Health Statistics; NHANES II, Second National Health and Nutrition Examination Survey; SES, socioeconomic status.

al. 1988). Six interviewers were trained for 8 wk and the four with the lowest average intraobserver technical errors of measurement were selected. Their average technical errors were lower than the corresponding NCHS/WHO values for all measurements (Cameron 1984). Two interviewers carried out each measurement and the mean value was used in the analyses.

For describing the nutritional status of the sample, weight-for-age, height-for-age and weight-for-height deficits were defined using the -2 SD cut-off of the NCHS/WHO reference (U.S. Department of Health, Education and Welfare 1978), and overweight was defined using the corresponding $+2$ SD cut-off of weight for height. For the other analyses, all anthropometric variables were treated as continuous. The statistical analyses included ANOVA for comparing the mean anthropometric measurements of low and high SES children, with adjustment for skin color (dummy variable, Caucasian/other), age in months and age squared (because a quadratic equation improved the fit for the age variable). These mean values were also compared with the mean Second National Health and Nutrition Examination Survey (NHANES II) U.S. Department of Health and Human Services (DHHS) 1987 values using a one-sample t test. The statistical significance level was set at 5%.

Informed consent was obtained from all parents and confidentiality was ensured. The proposal was approved by the Scientific and Ethical Committee of the School of Medicine of the Federal University of Pelotas.

RESULTS

The two samples presented marked differences in maternal and paternal education, and in housing and sanitation indicators (**Table 1**). Maternal work outside the home was more frequent in the high SES area.

The demographic characteristics of children from the low and high SES neighborhoods are presented in **Table 2**. There were no significant differences between the two areas in terms of the children's ages and sex. There were five times more non-Caucasian children in the low SES area, as well as more teenage mothers and higher parity.

Morbidity indicators were also higher in the poor area. Diarrhea was reported in the preceding 2 wk for 25% of the children in this area vs. 6% in the high SES neighborhood. Hospital admissions in the previous 12 mo were also more common among the poor (19 versus 2%).

TABLE 1

Distribution of socioeconomic variables among Brazilian children of low and high SES (Pelotas, RS/Brazil, 1995)[1]

	Low SES (*n* = 96)		High SES (*n* = 101)		
Variable	*n*	%	*n*	%	*P*
Maternal schooling, *y*					
0	7	7.3	0	—	<0.001**
1–3	28	29.2	1	1.0	
4–7	54	56.3	3	3.0	
≥8	7	7.3	97	96.0	
Paternal schooling, *y*					
0	9	9.9	0	—	<0.001**
1–3	33	36.3	0	—	
4–7	45	49.5	2	2.0	
≥8	4	4.4	99	98.0	
Maternal employment	38	39.6	60	59.4	0.006***
Number of rooms					
1–3	59	6.5	0	—	<0.001**
4–5	26	27.1	8	7.9	
6–10	11	11.5	54	53.5	
≥11	0	—	39	38.6	
Flush toilet	58	60.4	101	100.0	<0.001**

[1] Low or high SES, low or high socioeconomic level.
** Chi-squared test for linear trend.
*** Chi-squared test for heterogeneity.

TABLE 2

Demographic characteristics of Brazilian mothers and children of low and high SES (Pelotas, RS/Brazil, 1995)[1]

	Low SES (*n* = 96)		High SES (*n* = 101)		
Variable	*n*	%	*n*	%	*P*
Age of the child, *mo*					
12–17.9	17	17.7	21	20.8	0.4**
18–23.9	29	30.2	23	22.8	
24–29.9	30	31.3	28	27.7	
30–35.9	20	20.8	29	28.7	
Male sex	58	60.4	62	61.4	1.0***
White skin color	72	75.0	96	95.0	<0.001***
Age of the mother, *y*					
≤20	15	15.6	2	2.0	<0.001**
21–30	53	55.2	40	39.6	
>30	28	29.2	59	58.4	
Number of children					
1	20	20.8	44	43.6	<0.001**
2	30	31.3	39	38.6	
3	20	20.8	15	14.9	
≥4	26	27.1	3	3.0	

[1] Low or high SES, low or high socioeconomic level.
** Chi-squared test for linear trend.
*** Chi-squared test for homogeneity.

The anthropometric characteristics of both samples are shown in **Table 3**. Low birthweight was twice as common and the prevalences of stunting and underweight were nine times higher among the poor relative to the rich. There were no differences in prevalences of weight-for-height deficits (there was only one child in the sample with a low weight for height) or in overweight.

Maternal anthropometry also showed major differences, i.e., 21.3% of low SES mothers measured <150 cm, compared with 3% among the wealthy, and upper arm circumferences <23.5 cm were observed in 16.0 and 5.1%, respectively.

The crude and adjusted mean values of the anthropometric indices in the two SES groups are presented in **Table 4**. The adjusted differences between the groups are also shown, in both absolute as well as relative terms, expressed as a percentage of the value of the high SES group. Most indices were significantly lower among children from the low SES area. The most marked differences (>8% in relative terms) were observed for biceps skinfold, weight and mid-upper arm areas (muscle, fat and total). Significant differences ranging from 4 to 8% were also observed for subischial height, total height and sitting height or crown-rump length, and for upper arm circumference. Differences were not significant for chest and abdominal circumferences or for the three skinfolds (triceps, suprailiac and subscapular).

Table 5 presents the same indices as Table 4, divided by the child's height, indicating body proportionality. The differences are much smaller than in Table 4, and only weight and two upper arm areas (total and muscular) remain different. On the other hand, the ratio of abdominal circumference to height is larger among the low SES children.

Figure 1 summarizes the results of the present analyses, comparing the two groups of children with the NHANES II

TABLE 3

Birthweight and distribution of anthropometric indices among Brazilian children of low and high SES (Pelotas, RS/Brazil, 1995)[1]

	Low SES (n = 96)		High SES (n = 101)		
Variable	n	%	n	%	P
Birthweight, *g*					
<2.500	12	12.5	6	6.1	0.008**
2.500–2.999	28	29.2	14	14.1	
3.000–3.499	33	34.4	48	48.5	
≥3.500	23	24.0	31	31.3	
Height-for-age[2]					
< −2 SD	17	17.9	2	2.1	<0.001***
≥ −2 SD	78	82.1	92	97.9	
Weight-for-age					
< −2 SD	9	9.5	1	1.1	0.02***
≥ −2 SD	86	90.5	93	98.9	
Weight-for-height[2]					
< −2 SD	0	0	1	1.1	1.0***
≥ −2 SD	95	100.0	93	98.9	
Overweight[3]					
≥ +2 SD	3	3.2	4	4.3	1.0***
< +2 SD	92	96.8	90	95.7	

[1] Low or high SES, low or high socioeconomic level.
[2] Includes length or height.
[3] Weight-for-height > +2 Z-score.
** Chi-squared test for linear trend.
*** Chi-squared test for homogeneity.

data (U.S. DHHS 1987). High SES children were between 95 and 105% of the NHANES II mean values, except for two adiposity indices. The low SES group was significantly lower than the NHANES II values for all values except head circumference, but differences in bone dimensions were considerably smaller than those for muscle or fat.

DISCUSSION

For assessing differences in body proportions, it was necessary to compare low SES children who are exposed to malnutrition with a high SES sample selected to represent children with unconstrained growth. The selection process was successful, and the two samples were markedly distinct in terms of socioeconomic and demographic characteristics, as well as child morbidity. These findings are in agreement with the marked inequity in child health indicators observed in several Brazilian studies (Barros and Victora 1996, Monteiro 1995).

As a consequence of the stratified sampling scheme, the two groups of children also presented some ethnic differences, with a larger proportion of Caucasian children in the high SES group. The literature shows ethnic differences in growth and body composition, starting in early life (Brook 1982, Eveleth and Tanner 1990, Gibson 1990, Sinclair 1978). It was therefore decided that to adjust for skin color (a proxy for ethnicity) in all analyses. Analyses were also carried out for Caucasian children only, and the results were very similar.

The study was restricted to children aged 12–35.9 mo because this age range tends to present high prevalences of anthropometric deficits (Monteiro 1988, Victora et al. 1988). There were no significant differences among the two groups in terms of age; nevertheless, analyses were adjusted for exact age to exclude the possibility of residual confounding.

The two samples were markedly different in terms of most anthropometric indicators. Relative to the high SES children, the low SES sample presented twice as many incidences of low birthweight, eight times more stunting and nine times more

TABLE 4

Average anthropometric indices of Brazilian children of low and high SES (crude and adjusted) and differences between the two social groups (absolute and relative) (Pelotas, RS-Brazil, 1995)[1]

	Crude analysis			Adjusted analysis[2]				
Anthropometric variable	Low SES	High SES	P	Low SES	High SES	P	Differences Absolute	%[3]
Weight, *kg*	11.45	12.77	<0.001	11.52	12.70	<0.001	−1.18	−9.3
Height,[4] *cm*	82.61	87.06	<0.001	83.80	86.87	<0.001	−4.08	−4.7
Sitting height,[5] *cm*	50.50	53.08	<0.001	50.58	52.99	<0.001	−2.41	−4.6
Subischial height,[6] *cm*	32.12	33.96	0.002	32.17	33.91	<0.001	−1.74	−5.1
Head circumference, *cm*	47.65	48.54	<0.001	47.66	48.53	<0.001	−0.86	−1.8
Upper arm circumference, *cm*	15.14	15.96	<0.001	15.17	15.94	<0.001	−0.76	−4.8
Chest circumference, *cm*	49.17	49.79	0.1	49.20	49.75	0.1	−0.55	−1.1
Abdominal circumference, *cm*	47.57	47.81	0.6	47.67	47.71	0.9	−0.04	−0.1
Triceps skinfold, *mm*	8.15	8.45	0.2	8.15	8.45	0.2	−0.30	−3.6
Biceps skinfold, *mm*	5.43	6.00	<0.001	5.42	6.01	0.001	−0.59	−9.8
Subscapular skinfold, *mm*	6.03	6.23	0.3	6.03	6.23	0.3	−0.20	−3.3
Suprailiac skinfold, *mm*	7.18	7.00	0.5	7.18	7.00	0.6	0.19	2.7
Upper arm total area, *cm*^{2}	18.35	20.38	<0.001	18.42	20.31	<0.001	−1.88	−9.3
Upper arm muscle area, *cm*^{2}	12.64	14.15	<0.001	12.71	14.08	<0.001	−1.37	−9.7
Upper arm fat area, *cm*^{2}	5.68	6.22	0.01	5.70	6.20	0.02	−0.51	−8.2

[1] Low or high SES, low or high socioeconomic level.
[2] Adjusted for age, age^2 and skin color.
[3] $\text{Difference } \% = \dfrac{\text{mean among low SES children} - \text{mean among high SES children}}{\text{mean among high SES children}} \times 100.$
[4] Includes length measurement.
[5] Includes crown-rump length measurement.
[6] Includes subischial length measurement.

TABLE 5

Average ratios of anthropometric measurements to the child's height or length for Brazilian children of low and high SES (crude and adjusted) and differences between the social groups (absolute and relative) (Pelotas, RS-Brazil, 1995)[1]

Anthropometric ratio	Crude analysis Low SES	Crude analysis High SES	Crude analysis *P*	Adjusted analysis[2] Low SES	Adjusted analysis[2] High SES	Adjusted analysis[2] *P*	Differences Absolute	Differences %[3]
Weight/height[4]	0.1379	0.1460	<0.001	0.1384	0.1455	0.001	−0.0071	−4.9
Sitting height/height[5]	0.6122	0.6110	0.8	0.6123	0.6109	0.6	0.0014	0.2
Subischial height/height[6]	0.3878	0.3890	0.7	0.3878	0.3891	0.6	−0.0013	−0.3
Head circumference/height[4]	0.5785	0.5597	<0.001	0.5776	0.5606	<0.001	0.0170	3.0
Upper arm circumference/height[4]	0.1836	0.1841	0.8	0.1837	0.1840	0.8	−0.0003	−0.2
Chest circumference/height[4]	0.5971	0.5739	<0.001	0.5967	0.5744	<0.001	0.0223	3.9
Abdominal circumference/height[4]	0.5776	0.5512	<0.001	0.5776	0.5512	<0.001	0.0264	4.8
Triceps skinfold/height[4]	0.0989	0.0975	0.7	0.0986	0.0978	0.8	0.0008	0.8
Biceps skinfold/height[4]	0.0660	0.0694	0.1	0.0658	0.0696	0.07	−0.0038	−5.5
Subscapular skinfold/height[4]	0.0735	0.0722	0.6	0.0734	0.0723	0.7	0.0011	1.5
Suprailiac skinfold/height[4]	0.0874	0.0806	0.06	0.0872	0.0808	0.08	0.0064	7.9
Upper arm total area/height[4]	0.2217	0.2344	0.004	0.2223	0.2338	0.01	−0.0115	−4.9
Upper arm muscle area/height[4]	0.1530	0.1628	<0.001	0.1535	0.1622	0.003	−0.0087	−5.4
Upper arm fat area/height[4]	0.0688	0.0716	0.2	0.0688	0.0716	0.3	−0.0028	−3.9

[1] Low or high SES, low or high socioeconomic level.

[2] Adjusted for age, age^2 and skin color.

[3] $\text{Difference \%} = \dfrac{\text{mean among low SES children} - \text{mean among high SES children}}{\text{mean among high SES children}} \times 100.$

[4] Includes the measurements divided by length.

[5] Includes crown-rump length/length measurement.

[6] Includes subischial length/length measurement.

underweight. In accordance with what was expected, low weight-for-height prevalences were similarly low in both groups. There were no wasted children in the low SES group, and 1 child of 94 in the high SES group. This finding confirms the paradox that weight-for-height deficits are much lower than would be expected in the low SES group.

The summary of findings presented in Figure 1 shows that high SES children were very similar to the NHANES sample, except for triceps skinfold and upper arm fat area (85% of NHANES II mean), both related to each other and representing adiposity. Although some of other differences were significant, they are unlikely to be of practical relevance. This

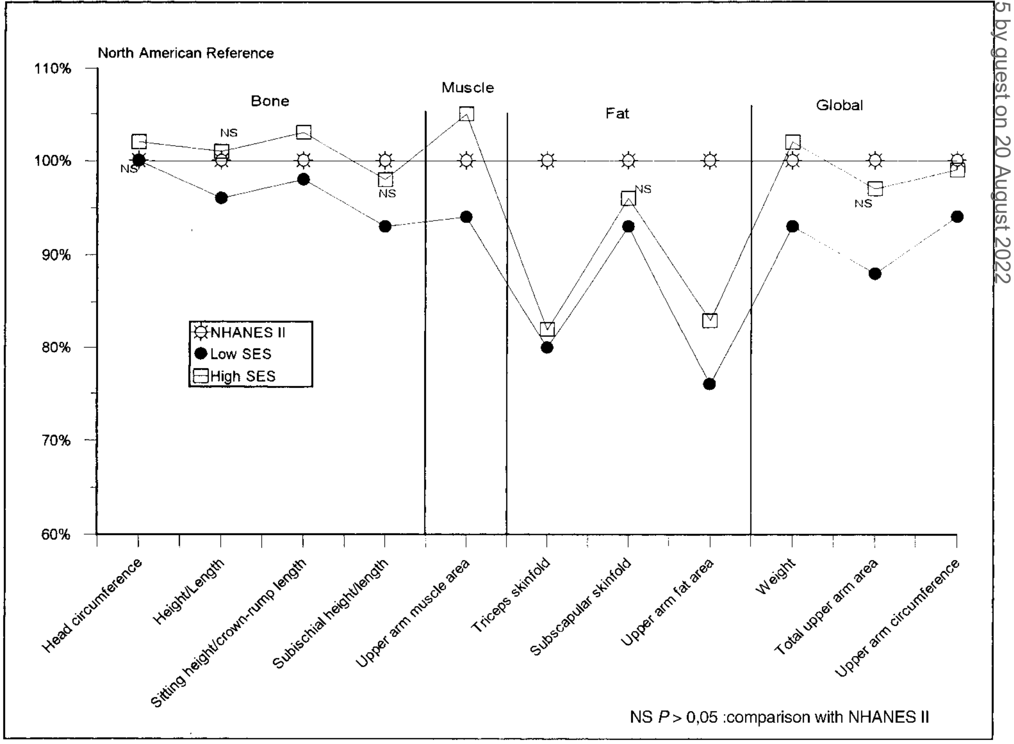

FIGURE 1 Comparison between the average measurements of high and low socioeconomic status Brazilian children, expressed as a percentage of the Second National Health and Nutrition Examination Survey (NHANES II) reference values (100%) (Pelotas, RS-Brazil, 1995).

confirms that our study was able to identify a group of children with largely unconstrained growth.

All measurements in the low SES sample tended to be lower than in the high SES group. Relative to NHANES II, all indices except head circumference were significantly lower.

A part of these differences might be explained by morbidity patterns. Studies in several countries confirm the effect of infection on growth (Martorell and Ho 1984, Tomkins and Watson 1989), and low SES children presented higher frequencies of diarrhea and hospital admissions, as well as marked differences in environmental conditions. Regarding dietary differences, breast-feeding duration did not vary markedly among social groups in the city of Pelotas, but there are important differences in the composition of weaning diets (Horta et al. 1996) that may affect growth.

These results show that low SES children from Pelotas tended to be smaller in size than either high SES children from the same site or children in the NHANES II sample. However, when body proportionality was assessed by dividing the measurements by the child's height, these differences tended to disappear or even to change direction, as was the case for head, chest and abdominal circumferences.

The findings on abdominal circumference were particularly interesting. This measurement was virtually identical between low and high SES children, and the former had larger circumferences for a given height. Because NHANES II did not include this measurement, the only available source of abdominal circumference data for U.S. children since 1950 appears to be the study by Snyder et al. (1975) (Roche, A., personal communication). The abdominal circumference for low SES Pelotas children was on average 2.1 cm (4.6%) greater than for Snyder's sample, and for high SES children, the difference was 2.3 cm (5.1%). However, the Lohman technique used in Pelotas differed slightly from that employed by Snyder, both in terms of the level at which the circumference is measured (largest circumference vs. natural waist, respectively) and Snyder's use of a constant tension tape, which is not recommended by Lohman. Six Pelotas children were measured using both waist levels, and the Pelotas technique resulted in average measurements that were only 0.2 cm larger. However, even though it was not possible to assess the effect of using a constant tension tape, we measured 10 children using both the Lohman technique (tape is held snug against the skin without compressing the tissues) and using strong compression (tape denting on the skin) to simulate the Snyder technique. The average differences between the two measures were 0.75 cm when the natural waist was measured and 0.92 cm for the maximum abdominal circumference. It is unlikely, therefore, that discrepancies in tape tension or measuring techniques could explain a 2-cm average difference in abdominal circumference.

Therefore, it seems plausible that differences in body proportions could explain, at least in part, the low prevalences of weight-for-height deficits in Brazilian children, despite high stunting prevalences. Low SES children present lower body fat indices, which would lead one to expect them to have lower weights for a given height. In other words, they would be "wasted." However, they also present, for a given height, higher circumference measures of the head, chest and, particularly, abdomen. Therefore, their apparently adequate weight for height is due to a combination of these two opposing changes.

It would be interesting to compare these results with those from other developing countries; however, despite a thorough literature search and communication with experts, it was not possible to find any such studies on abdominal circumference.

These findings suggest that the use of North American standards for assessing weight for height in Latin American populations deserves further evaluation because it may lead to underestimation of the true prevalence of wasting.

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