Fatness and body mass index from birth to young adulthood in a rural Guatemalan population[1–3]

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ABSTRACT Body mass index (BMI; wt in kg/ht^2 in m) has been proposed as a simple and valid measure for monitoring fatness. Using data from a 25-y longitudinal study of rural Guatemalans, we found that, as children, this population was stunted (mean height-for-age $z = -2.6$) and had low triceps skinfold thicknesses (≈10% of reference medians), yet had mean BMIs above US reference medians. As young adults, mean BMIs were at the 50th and 20th percentiles for women and men, respectively. BMIs between ages 1 and 5 y were moderately correlated (r = 0.2–0.3) with those in young adulthood. BMI was correlated with subscapular (r = 0.5–0.8) and triceps (r = 0.2–0.7) skinfold thicknesses at all ages and with predicted percentage body fat in adolescence (r = 0.65) and adulthood (r = 0.8). Fatness was highly centralized, with ratios of subscapular to triceps skinfold thicknesses at the 50th–90th percentiles of reference medians at all ages. BMI was a poor indicator of central fat; the correlation between BMI and waist-to-hip ratio in 14–17-y-old males was −0.21). In stunted populations in developing countries, BMI alone should be interpreted with caution. In stunted children, BMIs may be high despite small extremity skinfold thicknesses; BMI alone may overestimate the prevalence of fatness in these children. In adults, measures in addition to BMI may be required to identify centralized adiposity in these populations. *Am J Clin Nutr* 1999;70(suppl):137S–44S.

KEY WORDS Body mass index, fatness, overweight, stunting, Guatemala, tracking, skinfold thickness, anthropometry

INTRODUCTION

Overweight, particularly abdominal fatness, is a well-established risk factor for cardiovascular disease, type 2 diabetes, stroke, and mortality (1). Children who are overweight tend to be overweight as adolescents (2, 3) and young adults (4–7). The stability (ie, tracking) of fatness from childhood to adulthood, however, is variable and is modified by sex (8), age at measurement (9), and birth proportions (5), among other factors.

The prevalence of obesity and overweight is increasing worldwide. In the United States, for example, the prevalence of obesity among adults aged 24–74 y and adolescents aged 12–19 y increased ≈30% and 40%, respectively, between the late 1970s and early 1990s (10, 11). Overweight and obesity are also on the rise in many less-developed countries of the world (12). The causes of the higher rates of fatness in developing countries are poorly studied but likely include the extreme and rapid changes in lifestyle, physical activity, and diet that accompany urbanization and rapid economic development (13). The results of such lifestyle changes are already being seen—most cardiovascular disease deaths, generally associated only with Western industrialized countries, now occur in developing countries (14).

To better document and understand the global trend toward increasing overweight, standard measures and reference values for fatness should be adopted. Toward this goal, the body mass index (BMI; wt in kg/ht^2 in m) has been proposed as a simple, accurate, and valid measure of fatness in childhood and adolescence that could be used worldwide (15, 16). The advantages of BMI are that it is easy to compute, is relatively independent of stature (17–19), and correlates with other indexes of fatness (20–23). The vast majority of studies that have examined the degree to which BMI remains similar from childhood to adulthood and whether BMI is a good reflection of fatness, however, have been conducted in populations living in the industrialized world. Use of BMI as an indicator of fatness during childhood and adolescence has received less attention in malnourished, developing-country populations in which stunting and wasting are common.

The objectives of this article were to examine *1*) the degree to which BMI tracks from infancy to young adulthood and *2*) the correlation between BMI and other indicators of fatness, by using data from a 25-y longitudinal study of rural Guatemalans.

METHODS

Subjects

The study population was drawn from 1373 subjects who were measured as children in a longitudinal study conducted by the Institute of Nutrition of Central America and Panama (INCAP) and collaborating US universities in 1969–1977 in 4 villages in rural Guatemala. Detailed descriptions of the sample, methods, and quality control of this study were published previously (24). Briefly, 4 impoverished Latino villages (ie, with a

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[2] Supported by The National Institutes of Health (grants HD29927, HD22440, and HD33468) and the Thrasher Research Fund.

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TABLE 1
Body size and indexes of fatness for select ages[1]

Sex and age	Weight	Length or stature[2]	BMI	Skinfold thickness: Triceps	Skinfold thickness: Subscapular	Skinfold thickness: Sub:Tri	Skinfold thickness: Trunk: extremity	Skinfold thickness: Upper: lower	Percentage fat	WHR (× 100)
	kg	*cm*	*kg/m²*	*mm*	*mm*				*%*	
Females										
Birth (n = 364)	3.0 ± 0.4	—	—	—	—	—	—	—	—	—
15 d (n = 338)	3.3 ± 0.5	48.4 ± 2.2	13.9 ± 1.6	5.1 ± 0.9	5.5 ± 1.1	1.09 ± 0.16	0.51 ± 0.06	1.85 ± 0.24	—	—
18 mo (n = 379)	8.4 ± 1.0	71.3 ± 3.1	16.5 ± 1.3	6.1 ± 1.2	5.2 ± 1.0	0.88 ± 0.18	0.39 ± 0.06	1.52 ± 0.22	—	—
36 mo (n = 335)	11.2 ± 0.9	83.8 ± 3.8	16.4 ± 1.2	7.0 ± 1.9	5.6 ± 1.2	0.82 ± 0.17	0.39 ± 0.07	1.73 ± 0.54	—	—
14–17 y (n = 273)	44.5 ± 7.2	148.9 ± 5.5	20.0 ± 2.8	14.9 ± 4.1	13.0 ± 4.9	0.98 ± 0.24	0.46 ± 0.14	2.27 ± 0.53	25.7 ± 3.5	89.8 ± 5.1
18–25 y (n = 547)	49.6 ± 7.7	150.1 ± 5.7	22.0 ± 3.1	14.8 ± 4.4	15.0 ± 5.4	1.02 ± 0.25	0.54 ± 0.14	2.37 ± 0.59	26.2 ± 3.5	91.0 ± 6.2
Males										
Birth (n = 388)	3.1 ± 0.5	—	—	—	—	—	—	—	—	—
15 d (n = 357)	3.4 ± 0.5	49.4 ± 2.4	14.1 ± 1.4	4.9 ± 0.9	5.3 ± 1.1	1.08 ± 0.14	0.50 ± 0.05	1.82 ± 0.23	—	—
18 mo (n = 395)	9.0 ± 1.1	72.9 ± 3.4	16.8 ± 1.3	6.1 ± 1.3	5.1 ± 1.0	0.86 ± 0.18	0.39 ± 0.07	1.56 ± 0.25	—	—
36 mo (n = 362)	11.5 ± 1.0	85.2 ± 3.9	16.6 ± 1.2	6.8 ± 1.3	5.3 ± 1.1	0.79 ± 0.15	0.38 ± 0.06	1.73 ± 0.25	—	—
14–17 y (n = 266)	45.6 ± 7.9	156.0 ± 9.1	18.6 ± 1.8	6.7 ± 1.8	6.9 ± 1.6	1.07 ± 0.27	0.57 ± 0.13	2.39 ± 0.52	11.6 ± 2.1	90.3 ± 4.6
18–25 y (n = 319)	55.5 ± 6.8	162.5 ± 5.6	21.0 ± 2.1	6.9 ± 2.6	9.9 ± 3.6	1.47 ± 0.37	0.83 ± 0.20	3.30 ± 0.74	12.8 ± 2.5	90.1 ± 3.8

[1] $\bar{x}$ ± SD. Sub:Tri, subscapular: triceps; Trunk:extremity, subscapular:(triceps+calf); Upper:lower, (subscapular+triceps):calf; WHR, waist-to-hip ratio.
[2] Length at 15 d and 18 mo and length −1 cm at age 36 mo were used to create BMI for comparability with reference 35.

Spanish-speaking population of mixed Spanish-Indian ancestry) were randomly assigned to receive either a high-protein, high-energy, drink (*atole*; 2 villages) or a low-energy, nonprotein drink (*fresco*; 2 villages). Supplements were prepared from original recipes by INCAP staff and were available daily at feeding centers to all members of the community. A preventive and curative health program was offered in all villages. Institutional review boards at INCAP and collaborating US universities approved the original research protocol. Energy from supplementation of pregnant women was associated with significantly heavier babies (25) and consumption of atole by children was associated with better child growth in height and weight but not in skinfold thicknesses (26, 27). In 1988–1989, a follow-up study located and reexamined 1047 subjects who were measured as children in the 1969–1977 study (28), of which 138 (13.2%) had migrated from the villages to a nearby town or to Guatemala City. From 1991 to 1994, adult measures were collected annually for women only. Supplementation with atole in childhood was significantly associated with greater height, weight, and fat-free mass but not fat mass in young adulthood (29).

Measurements

All measurements were conducted by trained fieldworkers in the communities using standard, previously published methods (24), described here only briefly. The quality of the data was monitored closely in both the 1969–1977 (30) and follow-up (28) studies. The precision and reliability of all measurements were high (30, 31).

Infant and child measures

Weight was measured at birth. Weight, supine length, and skinfold thicknesses were measured at 15 d and within 7 d of ages 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, 42, 60, 72, and 84 mo. BMI and weight-for-height z scores (32) were calculated after subtracting 1 cm from supine length taken between 24 and 84 mo of age for comparability with reference height values. Three skinfold thickness indexes of body-fat patterning were created: subscapular:triceps (Sub:Tri), subscapular:(triceps+calf) (Trunk:Extremity), and (subscapular+triceps):calf (Upper:Lower).

Adolescent and adult fatness and distribution

Height, weight, skinfold thicknesses, and circumferences were measured by using standard techniques (24, 33). Percentage body fat was calculated as a function of weight and fat-free mass. Fat-free mass was calculated with sex-specific prediction equations based on anthropometry developed through a densitometric study of Guatemalans matched to the subjects on age, anthropometric measurements, and ethnic origin (34). Waist-to-hip ratio (×100) was used as an indicator of abdominal fatness. The same 3 skinfold indexes (Sub:Tri, Trunk:Extremity, and Upper:Lower) were created for the adolescents and adults measured.

Statistical analysis

Analyses were confined to the 585 men measured in 1969–1977 who were 14–25 y old in 1988–1989 and to the 621 women who were 14–25 y old and had one or more nonpregnant measures taken in 1988–1989, 1991–1994, or both. Repeat anthropometry measures were averaged for women aged 14–17.9 and 18–25.9 y. Pearson product-moment correlation coefficients were computed among BMIs of individuals at all ages and between BMIs and other indicators of fatness at select ages. Data for males and females were analyzed separately. Analyses were done using SAS for WINDOWS (version 6.11; SAS Institute Inc, Cary, NC).

RESULTS

Sample sizes and means (with SDs) of the subjects' weight; height; BMI; triceps and subscapular skinfold thicknesses; skinfold indexes during childhood, adolescence, and adulthood; and percentage fat and waist-to-hip ratio during adolescence and adulthood are shown in **Table 1**. Both men and women in this population were highly stunted as children. At 15 d of age, subjects were moderately stunted (mean length-for-age z = −1.0) but not wasted (weight-for-length z = −0.03). By 36 mo, however, chil-

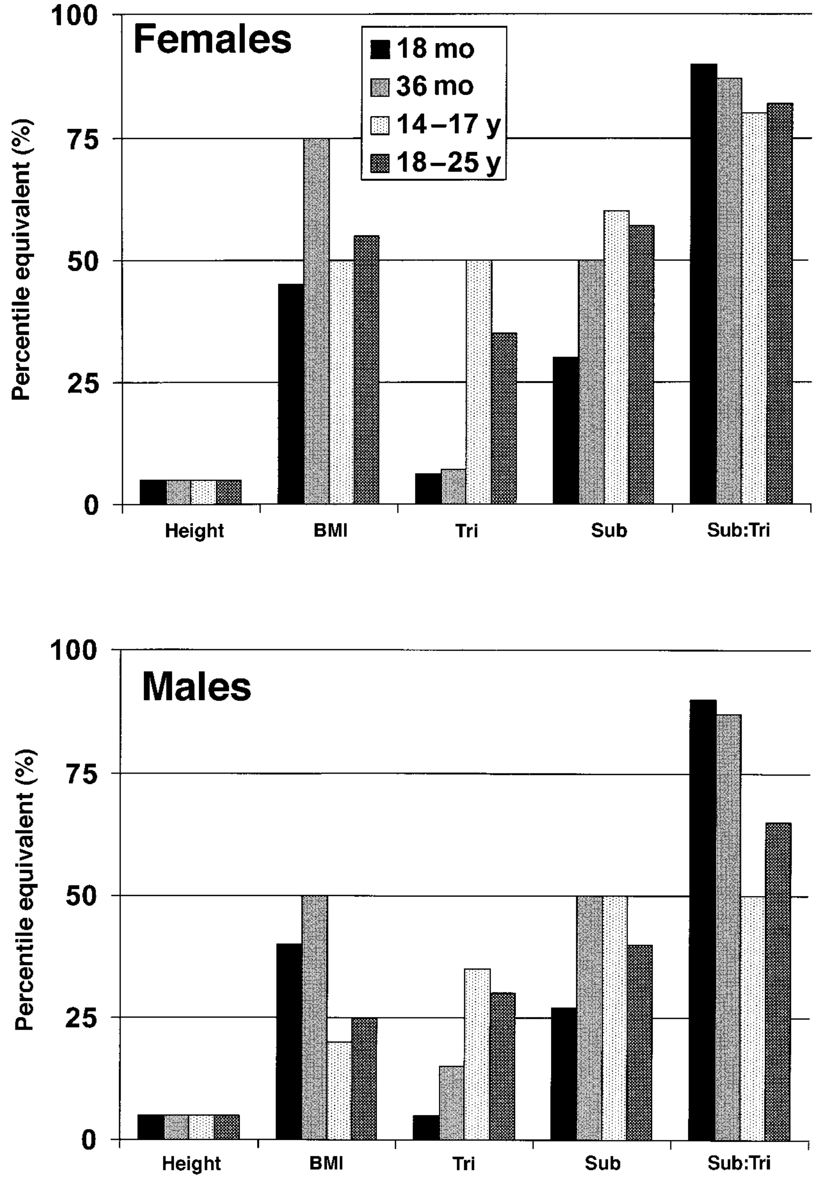

FIGURE 1. Percentile equivalent of mean height, BMI, triceps (Tri) and subscapular (Sub) skinfold thicknesses, and ratio of Sub to Tri skinfold thicknesses (Sub:Tri) in females (top) and males (bottom) at 18 m, 36 m, 14–17 y and 18–25 y of age compared with US reference values (35). Sample sizes (per mean) ranged from 266 to 547 (*see* Table 1).

dren were severely stunted (height-for-age $z = -2.6$). Adolescent and adult heights were below the 5th percentile of reference values (35) (**Figure 1**).

Despite poor diets and illnesses that led to linear growth retardation in childhood, BMI values during childhood were at or above reference medians. In adolescence and adulthood, BMIs were at approximately the 50th percentile in women and the 25th percentile in men. Fifteen percent of adult women and 6% of adult men had BMIs ≥25. Absolute triceps skinfold thicknesses did not increase in men from childhood to adulthood, but increased significantly in women during adolescence. Subscapular skinfold thicknesses did not increase during childhood, but increased in both men and women after adolescence. Compared with reference values, triceps skinfold thicknesses were significantly lower than reference medians, especially in childhood, whereas subscapular skinfold thicknesses were near the reference median at all ages. Consequently, Sub:Tri was high and ranged from the 50th to the 90th percentile.

In summary, as children, these rural Guatemalans were extremely short, yet had BMIs at or above the reference medians of a US reference population. Skinfold measures indicated that they had thinner extremities and more centralized fat patterning than the US reference. As young adults, BMI values were lower in both men and women relative to reference values, but were still above the 50th percentile in women. Body fat remained centralized in young adulthood.

Correlation matrixes for childhood BMIs by age are shown in **Table 2** for females and in **Table 3** for males. During childhood,

TABLE 2
Pearson's product-moment correlations (*r*) matrix of BMI for female longitudinal participants from 15 d to 84 mo of age[1]

Age	3 mo	6 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo	72 mo	84 mo
15 d	0.54 [299][2]	0.32 [286][2]	0.20 [266][3]	0.26 [234][2]	0.20 [224][4]	0.22 [164][4]	0.27 [124][4]	0.16 [64]	0.40 [28][5]	
3 mo		0.75 [341][2]	0.49 [321][2]	0.41 [286][2]	0.30 [276][2]	0.27 [219][2]	0.25 [183][3]	0.29 [115][4]	0.26 [74][5]	0.23 [35]
6 mo			0.65 [332][2]	0.46 [300][2]	0.34 [288][2]	0.25 [224][2]	0.26 [183][3]	0.27 [126][4]	0.32 [83][4]	0.09 [41]
12 mo				0.59 [330][2]	0.53 [320][2]	0.45 [250][2]	0.46 [210][2]	0.46 [145][2]	0.45 [101][2]	0.28 [55][5]
18 mo					0.62 [332][2]	0.52 [262][2]	0.50 [217][2]	0.57 [155][2]	0.52 [118][2]	0.37 [72][4]
24 mo						0.71 [283][2]	0.62 [235][2]	0.60 [165][2]	0.59 [128][2]	0.55 [84][2]
36 mo							0.75 [258][2]	0.72 [199][2]	0.69 [156][2]	0.68 [109][2]
48 mo								0.75 [201][2]	0.78 [157][2]	0.70 [111][2]
60 mo									0.78 [184][2]	0.74 [132][2]
72 mo										0.84 [139][2]

[1] *n* in brackets.
[2] $P < 0.0001$.
[3] $P < 0.001$.
[4] $P < 0.01$.
[5] $P < 0.05$.

intercorrelations among BMI values are fairly stable over the short term. BMI values during infancy (ie, <1 y of age) had lower correlations among one another than values taken between 1 and 7 y of age. BMIs taken between ages 3 and 7 y were highly correlated with correlation coefficients on the order of 0.6–0.7.

Correlation coefficients between BMIs taken at various ages during childhood and those taken when the same individuals were either adolescents (14–17 y old) or adults (18–26 y old) at follow-up are shown in **Figure 2**. The correlations between BMIs at infancy and at adolescence or adulthood were generally higher in females than males; correlations between BMIs at age 15 d and later BMIs were particularly low in males. The correlation between BMIs taken at age 12–42 mo and at adolescence or adulthood was ≈0.3 and fairly stable. At ≈5 y of age, the correlations between childhood and adolescent or adult BMIs were ≈0.4–0.5.

Correlation coefficients between BMIs and the indicators of fatness at the same time of measurement at ages 15 d, 18 mo, 36 mo, 60 mo, adolescence (14–17 y), and young adulthood (18–26 y) are shown in **Table 4**. BMI was most highly correlated with the triceps and subscapular skinfold thicknesses; correlations at age 15 d and adulthood were particularly strong. BMI was significantly correlated with Sub:Tri in women, but generally only weakly so in men. In adolescence and adulthood, BMI values correlated more strongly with the other indicators of fatness in women than men. The negative correlation between BMI and waist-to-hip ratio in adolescent men is noteworthy (**Figure 3**).

DISCUSSION

Most studies that have examined the stability of BMI and the usefulness of BMI as an indicator of fatness have been conducted in white populations in industrialized countries. For this article, we analyzed data from a longitudinal study of a poor, rural, Latino population in Guatemala in which high rates of infection and poor diet led to severe childhood and adult stunting (24). Despite these deprived conditions, BMI values were at or above reference means in childhood in both boys and girls and remained above the 50th percentile in women through young adulthood. Skinfold thickness indexes and the waist-to-hip ratio indicated that body fat in these subjects was centralized relative to US populations (35, 36). We found BMI at age 15 d to be a moderate predictor of BMI in adolescence or adulthood in

TABLE 3
Pearson's product-moment correlations (*r*) matrix of BMI for male longitudinal participants from 15 d to 84 mo of age[1]

Age	3 mo	6 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo	72 mo	84 mo
15 d	0.47 [320][2]	0.31 [304][2]	0.28 [276][2]	0.26 [260][2]	0.29 [231][2]	0.34 [180][2]	0.29 [130][3]	0.16 [60][2]	−0.12 [21]	
3 mo		0.77 [341][2]	0.60 [319][2]	0.42 [298][2]	0.34 [268][2]	0.39 [220][2]	0.32 [169][2]	0.23 [95][4]	0.19 [51]	0.49 [28][5]
6 mo			0.71 [341][2]	0.49 [326][2]	0.35 [295][2]	0.34 [249][2]	0.25 [199][3]	0.15 [126]	0.18 [82]	0.23 [43]
12 mo				0.67 [346][2]	0.51 [318][2]	0.50 [273][2]	0.43 [220][2]	0.39 [149][2]	0.36 [95][3]	0.35 [57][2]
18 mo					0.67 [345][2]	0.56 [293][2]	0.50 [237][2]	0.44 [168][2]	0.46 [112][2]	0.46 [75][2]
24 mo						0.65 [307][2]	0.62 [250][2]	0.55 [181][2]	0.51 [124][2]	0.51 [88][2]
36 mo							0.74 [287][2]	0.66 [214][2]	0.67 [156][2]	0.62 [110][2]
48 mo								0.76 [238][2]	0.68 [180][2]	0.59 [138][2]
60 mo									0.80 [207][2]	0.72 [162][2]
72 mo										0.79 [171][2]

[1] *n* in brackets.
[2] $P < 0.0001$.
[3] $P < 0.001$.
[4] $P < 0.05$.
[5] $P < 0.01$.

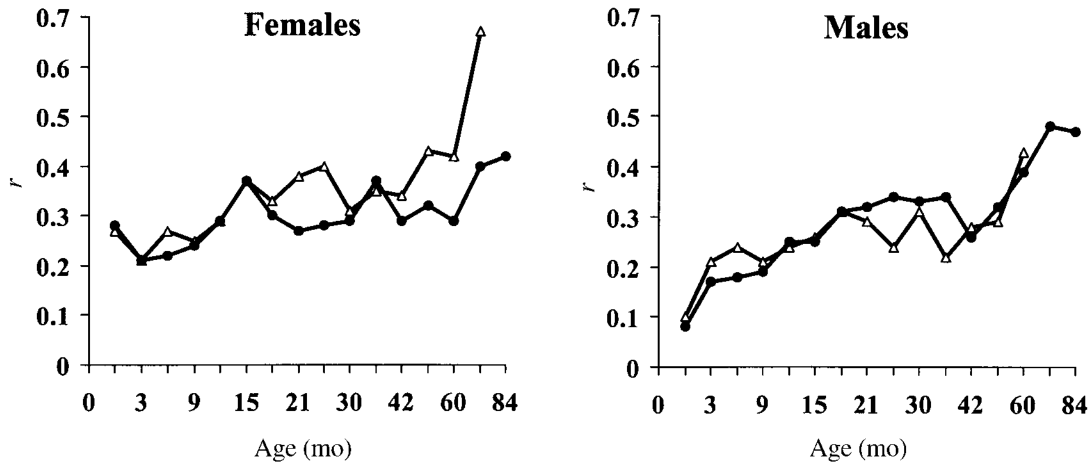

FIGURE 2. Correlation coefficients between BMI in late adolescence (△, age 14–17 y) and young adulthood (●, age 18–25 y) and childhood BMI from age 15 d to 7 y.

women, but a poor predictor of adolescent or adult BMI in males. Between the ages of 1 and 5 y, the correlation of BMI with adolescent or young-adult BMI was moderate and stable at ≈0.3. BMIs in older childhood (ie, 5–7 y) were better correlated among those ages and with adolescent or young-adult BMIs. As an indicator of fatness, BMI correlated highly with subscapular and triceps skinfold measures at all ages and with predicted total percentage body fat in adolescence and adulthood. The inclusion of weight in the prediction equation of percentage body fat (34) is likely contributing to this high correlation. BMI was a poor reflection of the centralized nature of fat distribution in this population, particularly in men.

The degree to which BMI remained stable during childhood in this population was generally lower than reported elsewhere. For example, in an urban, Swiss population, Gasser et al (37) found that correlations between BMI at age 1 y and BMI at ages 2, 4, and 6 y ranged from 0.59 to 0.81, whereas those in our Guatemalan study ranged from 0.46 to 0.53. Between childhood and young adulthood, the magnitude of BMI correlations were similar for women in the Swiss population compared with Guatemalan popu-

TABLE 4
Pearson's product-moment correlations between BMI (in kg/m^2) at ages 15 d, 18 mo, 36 mo, 60 mo, adolescence (age 14–17 y), and young adulthood (age 18–24 y) with other indicators of fatness at these ages[1]

	r for BMI at age					
	15 d	18 mo	36 mo	60 mo	14–17 y	18–25 y
Females						
Skinfold thickness						
Triceps (mm)	0.60[2]	0.33[3]	0.26[3]	0.42[3]	0.49[3]	0.70[3]
Subscapular (mm)	0.66[3]	0.53[3]	0.53[3]	0.55[3]	0.76[3]	0.78[3]
Skinfold thickness index						
Sub:Tri	0.20[3]	0.13[4]	0.17[3]	0.13[2]	0.31[3]	0.27[3]
Trunk:extremity	0.12[2]	0.22[3]	0.27[3]	0.14[4]	0.32[3]	0.21[3]
Upper:lower	−0.12[4]	0.18[3]	0.07	0.11	0.03	0.02
Percentage fat	—	—	—	—	0.68[3]	0.85[3]
Waist-to-hip ratio	—	—	—	—	0.34[3]	0.48[3]
Males						
Skinfold thickness						
Triceps	0.53[3]	0.42[3]	0.48[3]	0.46[3]	0.36[3]	0.59[3]
Subscapular	0.60[3]	0.55[3]	0.56[3]	0.54[3]	0.65[3]	0.68[3]
Skinfold thickness index						
Sub:Tri	0.15[4]	0.13[4]	0.09	−0.05	0.25[3]	0.09
Trunk:extremity	0.17[4]	0.21[3]	0.20[3]	−0.00	0.28[3]	0.07
Upper:lower	0.02	0.20[3]	0.14[2]	0.07	0.14[2]	0.06
Percentage fat	—	—	—	—	0.63[3]	0.73[3]
Waist-to-hip ratio	—	—	—	—	−0.21[3]	0.41[3]

[1] Sub:Tri, subscapular:triceps; Trunk:extremity, subscapular:(triceps + calf); Upper:lower, (subscapular + triceps):calf.
[2] $P < 0.05$.
[3] $P < 0.001$.
[4] $P < 0.01$.

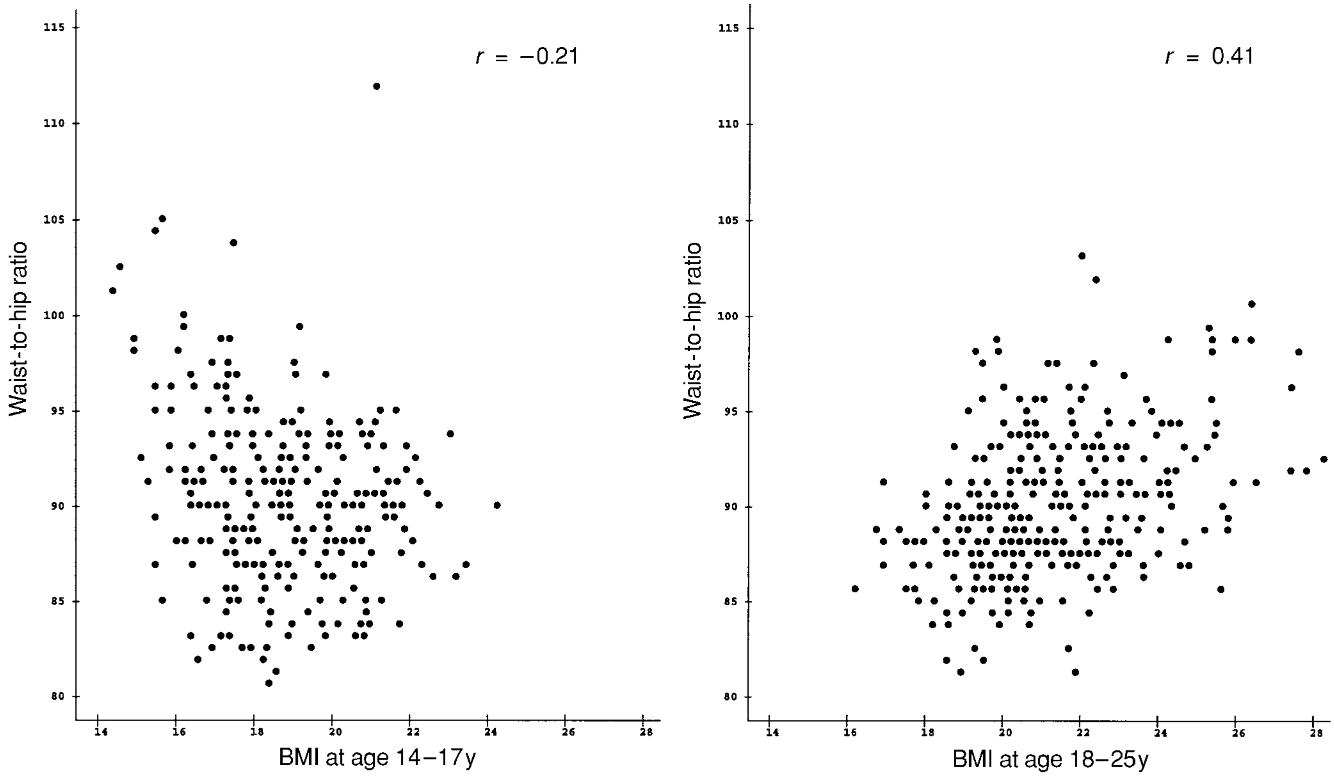

FIGURE 3. Plot of BMI versus waist-to-hip ratio in male adolescents (aged 14–17 y) and young adults (aged 18–25 y).

lations. For men, however, correlations between the Swiss adult and childhood BMIs were 0.26–0.65 but were only 0.1–0.47 for comparable ages in our Guatemalan sample. The lower level of stability seen in our Guatemalan sample might be due to the differences in body composition, the relative leanness of the Guatemalan compared with the Swiss males, or both.

This rural Guatemalan population was highly stunted but not wasted, according to BMIs, as either children or adults. This apparent paradox between the presence of severe stunting due to poor diet and infection and adequate or even excess weight-for-height seen in this Latino population in childhood and in adult women was described previously (38, 39), but remains unresolved. In such populations, it may be that the higher weight-for-height does not reflect fatness only. In Peru, Trowbridge et al (39) used H_2O^{18} stable isotope dilution to examine fatness and fat distribution in 139 stunted yet heavy preschool-age children, and found that skinfold thicknesses and fat area were lower but total body water was higher in these children compared with reference values. Trowbridge et al (39) thus concluded that the high weight-for-height values observed in these short children should not be considered obesity, but a reflection of greater lean tissue or lean tissue hydration. Another explanation is that malnourished children may have altered body proportions, with short legs and relatively long trunks, giving higher weight-for-height values (38). Finally, although weight-for-height indexes such as BMI are supposed to be independent of height, Freeman et al (40) found substantial and systematic associations of these measures with height at both ends of the weight and height spectrum in a well-nourished population; this would be particularly relevant in a stunted population such as this one.

The inability of BMI to assess fat distribution may be particularly limiting for studies in overweight but not necessarily obese populations in developing countries. The high trunk fatness found in this study is consistent with studies in Hispanic populations living in the United States (41). The ability to quantify centralization of fatness is important as researchers study the determinants and effects of the nutritional and demographic transition in developing countries. For example, an intriguing hypothesis for why cardiovascular disease is increasing so dramatically in developing countries is that exposure to undernutrition in utero or in infancy predisposes individuals to high-risk (ie, abdominal) fat patterning if they are exposed to ample food as a result of economic development or migration to urban settings later in life (42, 43). Evidence for this “fetal-origins” hypothesis (43) comes from animal studies that found that rats malnourished in utero tended to become overweight as adults (44–47) and human studies that found associations between exposure to famine in utero during early pregnancy and adult obesity (48) and between low birth weight and high waist-to-hip ratio (49, 50). In our Guatemalan population, stunting in childhood and low birth weight were associated with increased waist-to-hip ratio in both men and women, but only after total percentage body fat or BMI were controlled for (51). In other words, lower-birth-weight infants had lower total body fat as adults, but more of their fat was abdominal.

Conclusion

We found a low-to-moderate level of stability (ie, correlations between 0.3 and 0.7) in BMI between childhood and young adulthood in a rural, Guatemalan population. Whereas BMI was a good indicator of overall fatness in these individuals, it was a poor indicator of the highly centralized nature of the deposition of fatness, especially in men. We recognize that BMI is an easily calculable measure of heaviness and may be useful for monitoring extreme changes in fatness. Several physiologic and technical issues, however, affect whether BMI accurately reflects fatness. Some such factors (eg, extreme growth retardation) may be more prevalent in developing countries. As such, BMI should be interpreted with caution, especially when comparisons are made across countries (52) or among population subgroups or cohorts that may differ in height (40) or genetic makeup. In stunted children, BMIs may be equal to or greater than US reference values despite low extremity skinfold thicknesses; use of BMI in these children may overestimate fatness. In adults, especially young men, measures in addition to BMI may be required to identify the centralized nature of fat deposition in these populations.

We are grateful to the Guatemalan participants in this study for their continued cooperation and to Morgen Hughes for the computer analyses.

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