

Mild Stunting is Associated with Higher Blood Pressure in Overweight Adolescents

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Abstract

Background: Studies have shown that pre/postnatal undernutrition leads to higher risk of non communicable diseases such as diabetes, hypertension and obesity in adulthood.

Objective: To determine whether overweight adolescents with mild stunting [height-for-age Z scores (HAZ) in the range <-1 to ≥-2] have higher blood pressure than overweight individuals with normal stature (HAZ ≥ -1).

Methods: Participants were classified as mildly stunted or of normal stature, and further stratified according to body mass index-for-age percentiles as overweight, normal or underweight. Systolic (SBP) and diastolic (DPB) blood pressures were determined according to guidelines, and abdominal fat was analyzed by dual energy X-ray absorptiometry.

Results: Mild stunted overweight individuals showed higher DBP values ($p=0.001$) than their underweight counterparts (69.75 ± 12.03 and 54.46 ± 11.24 mmHg, respectively), but similar to those of normal BMI. No differences were found in DBP values of normal, overweight and underweight individuals among the normal stature groups. An increase in SBP ($p=0.01$) among mild stunted individuals was found when those with overweight were compared to their underweight and normal BMI counterparts (114.70 ± 15.46 , 97.38 ± 10.87 and 104.72 ± 12.24 mmHg, respectively). Although no differences were observed in the means of SBP between mild stunted and normal stature groups, a significant intercept was found ($p=0.01$), revealing higher SBP among stunted individuals. There was a correlation between SBP and abdominal fat ($r=0.42$, $\rho=0.02$) in the stunted group.

Conclusions: Stunted individuals with overweight showed higher SBP than those of normal stature and overweight. These findings confirm that mild stunting increase the risk of future hypertension and alterations are evident at early age. (Arq Bras Cardiol 2012;98(1):6-12)

Keywords: Blood pressure, poverty, adolescent, overweight.

Introduction

Undernutrition is a global health problem, the consequences of which are particularly evident in developing countries where 32% of children younger than 5 years (178 million infants) are stunted¹. A representative study conducted in Brazil has shown that the prevalence of stunting among children and adolescents aged between 10 and 19 years varied according to economic class². Thus, while 22.1% of males with a monthly income of up to one quarter of a minimum salary were stunted, only 5.9% of those with monthly earnings of more than five minimum salaries suffered from the effects of stunting. The main causes of stunting include poor prenatal care, deficient weight gain during pregnancy, premature weaning or inadequate supplementary feeding, low educational level

of the mother, qualitative and/or quantitative insufficiency of food intake during childhood, and high frequency of infections³.

Several epidemiological studies have shown that children who had suffered from growth deficit during the intrauterine period or in early life tended to have a higher risk of developing non-communicable diseases such as diabetes, hypertension and obesity in adulthood⁴⁻⁶. Moreover, such risks appear to be dependent on the environmental conditions under which the individuals live⁷⁻⁹. According to recent studies of children and adolescents with nutritional stunting, reduction in linear growth during childhood increases the susceptibility to obesity¹⁰ and hypertension¹¹. Fernandes et al¹² reported that the average prevalence of hypertension among adolescents of low socioeconomic status and stunting was 21% and, within this group, the prevalence of systolic or diastolic blood pressures (SBP and DBP, respectively) above the 90th percentile (adjusted for height) was 51%. A study involving Brazilian adults from impoverished areas¹³ revealed that the association between stunting and hypertension was stronger in women (38.5%) than in men (18.4%), and that the prevalence of hypertension among obese stunted women was 50%. These

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findings highlight the positive relationship between increased body mass index (BMI) and hypertension, and also serve to demonstrate that stunting is a worsening factor¹⁴.

A World Health Organization (WHO) recommendation published in 2007¹⁵ amended the previous 1983 classification¹⁶ of children and adolescents with height-for-age Z scores (HAZ) between -2 and -1 from "mildly stunted" to "normal". The hypothesis tested in this study was that overweight children and adolescents with HAZ in this critical range exhibit higher blood pressure than their overweight counterparts without mild stunting and should not, therefore, be categorized as having normal stature. If this hypothesis is correct, then individuals with mild stunting would exhibit alterations in blood pressure similar to those found in individuals with moderate/severe stunting, thus indicating the need to consider more sensitive cut-off points in the classification of stature in order to prevent non-communicable diseases in adulthood.

Methods

The study was approved by the Committee of Ethics in Research of the Universidade Federal de São Paulo (protocol no. 0284/08). All of the procedures employed complied with the ethical principles contained in the Declaration of Helsinki as stated by the World Medical Association. Written informed consent was obtained from the participants, or their parents or legal guardians where appropriate, prior to the commencement of the study.

The cross-sectional study involved a sample population of 309 children and adolescents, with ages in the range 9 to 19 years, who were attending government-funded schools and other institutions located in impoverished areas near to the campus of UNIFESP. The sample size was determined on the basis of a maximum acceptable type II error rate (beta level) of 0.2 (i.e. 20%).

Socioeconomic and environmental data were obtained from the parents or legal guardians of the participants through a specific questionnaire. Weight was determined by single measurement using a Country Technologies (Gays Mills, WI, USA) model SD-150 platform scale with a capacity of 150 kg and a precision of 100 g. Stature was assessed by a trained researcher using a portable stadiometer (AlturExata; TBW, São Paulo, Brazil) with a precision to the nearest 0.1 cm. BMI values were determined as the quotient between weight and the square of the height (kg/m^2). Measurements were made with participants wearing light clothes and with bare feet.

Nutritional status was calculated using Centers for Disease Control and Prevention (CDC, Atlanta, GA, USA) Epi Info version 2000. The sample population was subsequently divided into two groups based on the original classification of mild stunting ($\text{HAZ} < -1$ to ≥ -2) and normal stature ($\text{HAZ} \geq -1$). Participants were further stratified according to BMI-for-age percentiles as overweight ($\geq 85^{\text{th}}$), normal ($> 5^{\text{th}}$ and $< 85^{\text{th}}$) or underweight ($\leq 5^{\text{th}}$) by comparison with standard reference values based on CDC 2000 growth charts for children and adolescents¹⁷.

Body composition, including fat mass, was assessed by dual energy X-ray absorptiometry (DXA) using a Hologic (Bedford, MA, USA) model QDR-4500 A densitometer. The equipment was calibrated prior to each series of measurements. Total

body fat and lean mass were estimated with the aid of the Hologic Enhanced Whole Body software package (version 8.26). The abdominal region of interest was manually defined by adjusting the lines between upper L1 and lower L4 to the inner costal margin of the whole body. Owing to the high cost of this technique, approximately 25% of the study population ($n = 80$) was evaluated with respect to body composition.

In order to classify participants according to pubertal development, all of them were examined by a pediatrician following the procedure described by Tanner¹⁸. Individuals who had attained the appropriate WHO cut-off points (defined as breast-stage 2 for girls and genitalia-stage 3 for boys) were considered to be in the pubertal stage, whereas those who had not reached these stages were considered pre-pubertal¹⁹.

Blood pressure was measured using a conventional sphygmomanometer equipped with an inflatable cuff appropriately sized to the age range of the participants. The individual was placed in a seated position and rested for 10 min, following which the cubital fossa was elevated to heart level and three measurements were carried out at 5 min intervals. SBP was determined at the onset of the first Korotkoff sound, while DBP was determined after the disappearance of the fifth Korotkoff sound²⁰. Blood pressure was expressed as the mean value \pm standard deviation of the three measurements.

Mean values of age, stature, weight, BMI and abdominal fat of the normal and mildly-stunted groups were compared using the Student *t* test. Two way analysis of variance (BMI cut offs versus stature group) and Tukey HSD post-hoc analysis were employed to compare SBP and DBP. Similar procedures were used to compare individuals following their further stratification according to gender and pubertal stage. We analyzed the correlation between SBP and percentage abdominal fat within the mildly stunted group. All analyses were performed using Statistica 6 for Windows (Statsoft, Tulsa, OK, USA) with the level of statistical significance set at $p < 0.05$.

Results

The study population ($n = 309$) comprised 165 (53.5%) males and 144 (46.5%) females, of whom 53.5% were in the pubertal phase. The mean daily per capita income was US\$ 4.00, characterising the population as poor (monthly family income US\$484328). Illiteracy amongst mothers and fathers was 11% and 5.6%, respectively. Approximately 10% of homes were inadequate shacks built wholly or partly with wood (average number of people per dwelling 6 ± 3.6).

There were no statistically significant differences between mildly stunted and normal children and adolescents with respect to age, height, BMI-for-age percentile and percentage of abdominal fat (Table 1). However, the mean weight and BMI values of those individuals classified as having mild stunting were smaller than those of normal individuals. Additionally, while 10.9% of mildly stunted individuals were underweight (BMI-for age $\leq 5^{\text{th}}$ percentile) and 16.8% were overweight (BMI-for age $\geq 85^{\text{th}}$ percentile), in the normal stature group only 4.7% were underweight whereas 41.4% were overweight. Similar results were obtained from analyses in which individuals

were further stratified according to gender and pubertal stage (data not shown).

According to the 2-way ANOVA results for SBP, the interaction was significant ($p = 0.01$) meaning that the 2 stature groups presented distinct behaviour patterns as related to BMI classification (Figure 1). In fact, within the mildly stunted group, SBP values of overweight individuals were significantly higher ($p = 0.02$) than those of individuals with normal weight (114.70 ± 15.46 and 104.72 ± 12.24 mmHg, respectively) whereas within the normal stature group, there were no significant differences between the SBP values of overweight and normal individuals (109.39 ± 10.93 and 109.45 ± 15.03 mmHg, respectively).

In relation to diastolic blood pressure, the overweight mild stunted group presented a significant increase in comparison to the underweight mild stunted group (69.75 ± 12.03 mmHg and 54.46 ± 11.24 mmHg, $p = 0.01$, respectively), being similar to normal BMI (62.44 ± 9.42 mmHg, $p = 0.15$). In the normal stature group, overweight individuals presented similar values of DBP (67.42 ± 10.30 mmHg) in comparison to underweight and normal BMI (56.11 ± 13.89 mmHg, $p = 0.46$; 63.16 ± 12.76 mmHg, $p = 0.11$, respectively) (Figure 1).

Within the mildly stunted group there was a weak, but statistically significant, correlation ($r = 0.42$, $p = 0.02$) between SBP and abdominal fat (Figure 2), while in the normal group the association between these variables was not significant ($r = 0.18$, $p = 0.15$).

Discussion

Several factors that are known to be associated with hypertension in adults have also been linked to increased blood pressure in childhood and adolescence¹⁴. Among the environmental factors associated with the physiopathology of hypertension, overweight has been recognised as the determining element not only in adults but also in children. Furthermore, stunting is believed to be associated with increased blood pressure²¹, although few studies have focused on this aspect.

The most recent recommendation of WHO¹⁵ modified the previous classification¹⁶ of children and adolescents with height-

for-age Z scores (HAZ) in the range of -2 and -1 from “mildly stunted” to “normal”. It is likely that earlier concerns about mild undernutrition, which formed the basis of previous studies, have somewhat diminished because of a worldwide decline in the prevalence of undernutrition accompanied by a dramatic increase in obesity among the younger segment of the population. However, the establishment of specific and sensitive cut-off points remains crucially important in the detection of nutritional dysfunction at an early age.

The results obtained in this study confirm the hypothesis that mildly stunted individuals have high blood pressure, and that this condition is worsened by overweight. This premise is further supported by the demonstration of a significant correlation between SBP and abdominal fat within the group of children and adolescents with mild stunting.

According to the Guidelines²², the diagnosis of hypertension must be validated by repeated measures, at least on three different occasions. In this study, a mean of three consecutive blood pressure measurements was performed on only one occasion, which is a limitation of study. The aim of this study, however, was not to determine a clinical diagnosis of hypertension but to detect any alterations in blood pressure values between children and adolescents with different nutritional status that could indicate increased risk of future disease.

Longitudinal studies have shown that children with increased blood pressure, including those with normal stature, tend to develop hypertension over their lifetime²³. Moreover, studies such as the Bogalusa Heart study²⁴, which evaluated 116 hypertensive adult patients, revealed that a large percentage of the population presented increased SBP or DBP during infancy (48 and 41%, respectively). By comparing children with normal (≥ 3.0 kg) and low (≤ 2.5 kg) birth weight, Franco et al²⁵ discovered that reduced birth weight correlated with impaired endothelial and brachial artery function, and increased SBP during the first ten years of life. The group of children with low birth weight presented increased levels of uric acid and diminished vascular elasticity, which could lead to the development of cardiovascular diseases (CVD) in adulthood. In a further study, Franco et al²⁶ evaluated BMI, lipid profile, serum uric acid and insulin sensitivity and their relationships with leptin, nitric oxide, homocysteine and reactive

Table 1 - Nutritional status of the study population

| Parameter | Mildly-stunted group (n = 119) | | | Normal group (n = 190) | | | p value |
|--------------------------------------|--------------------------------|---------|---------|-------------------------------|---------|---------|---------|
| | Mean \pm standard deviation | Minimum | Maximum | Mean \pm standard deviation | Minimum | Maximum | |
| Age (years) | 11.1 \pm 2.3 | 7.0 | 17.0 | 10.4 \pm 2.5 | 6.0 | 18.0 | NS |
| Height (cm) | 137.7 \pm 12.0 | 115.0 | 165.5 | 145.1 \pm 13.6 | 116.8 | 187.0 | NS |
| Height-for-age Z score | -1.49 \pm 0.3 | -1.99 | -1.0 | 0.25 \pm 0.8 | -1.0 | 2.97 | < 0.01 |
| Weight (kg) | 34.9 \pm 11.2 | 20.2 | 63.9 | 43.4 \pm 17.2 | 20.2 | 121.7 | < 0.01 |
| Body mass index (kg/m ²) | 18.0 \pm 3.4 | 12.6 | 27.4 | 20.0 \pm 5.0 | 11.8 | 39.3 | < 0.01 |
| Body mass index -for-age percentile | 45.0 \pm 31.8 | 0.1 | 96.1 | 64.2 \pm 31.5 | 0.1 | 99.6 | NS |
| Abdominal fat (%) | 22.4 \pm 11.8 | 7.0 | 47.0 | 23.9 \pm 10.7 | 11.0 | 51.0 | NS |

T-test. NS, not statistically significant

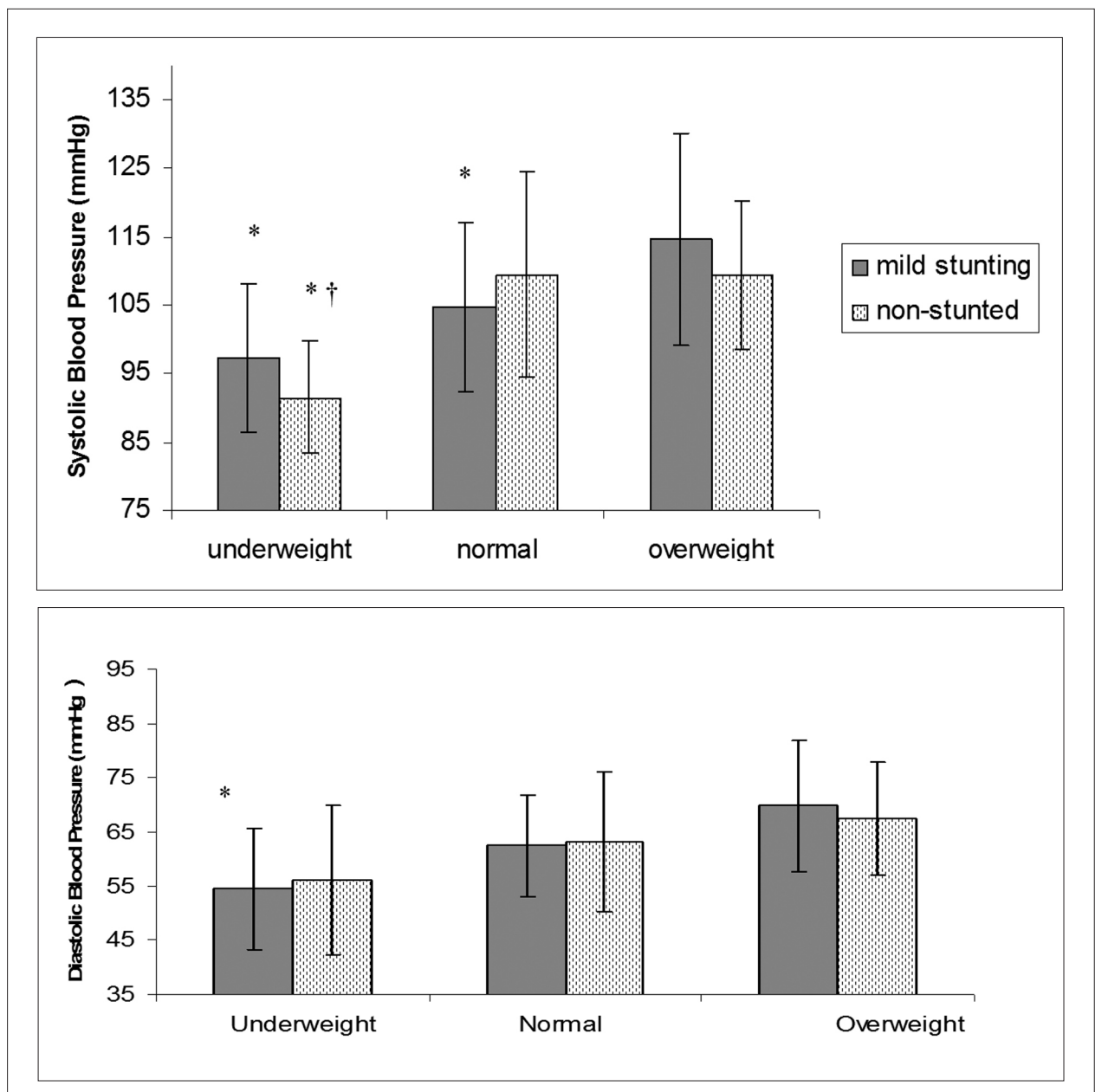


Figure 1 – Systolic and diastolic blood pressure (mean \pm standard deviation) in children and adolescents with mild stunting (height-for-age Z score <-1 to ≥-2) and normal stature (height-for-age Z score ≥-1) as a function of body mass index (underweight ≤ 5 th percentile; normal > 5 th to < 85 th percentile; overweight ≥ 85 th percentile). Two way ANOVA: BMI factor [$F(2,309) = 14,54; p = 0.01$], Stature factor [$F(1,309) = 0,88; p = 0,34$], Intercept factor [$F(2,309) = 4,44; p = 0,01$]. * $p < 0,05$ differs from overweight in the corresponding group. † $p < 0,05$ differs from normal in the corresponding group.

protein C in 69 children who had been classified as presenting normal ($n = 35$) or low ($n = 34$) weight at birth. Low birth weight was significantly associated with increased homocysteine and reduced nitric oxide levels. Since an increase in homocysteine leads to an elevation in SBP, while augmentation of nitric oxide generates a reduction in SBP, the risk of vascular and metabolic diseases in adulthood clearly correlates with alterations in the homocysteine and nitric oxide pathways and, consequently, with low weight at birth²⁶.

Our research group has recently found that the presence of mild stunting is also associated with higher levels of glucose and insulin, diminished function of beta cells, and increased insulin resistance²⁷.

Conclusions

In conclusion, this study demonstrated that overweight children and adolescents with mild stunting (HAZ <-1 to ≥-2) showed higher values of SBP in comparison with their

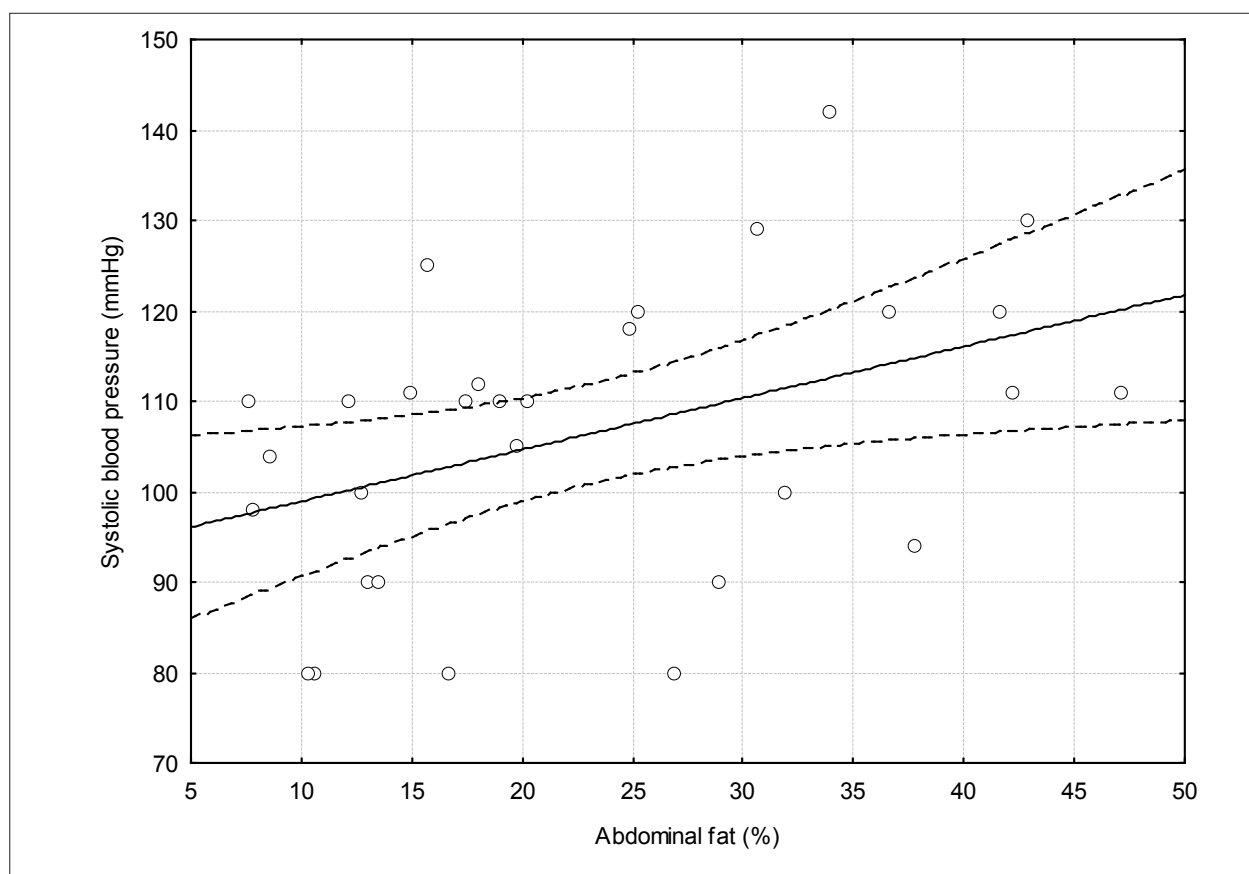


Figure 2 – Correlation between systolic blood pressure (SBP) and percentage abdominal fat among children and adolescents with mild stunting (height-for-age Z score <-1 to ≥-2). $SBP = 93.243 + (0.57057 \times \text{abdominal fat } \%)$; $r = 0.42178$; $p = 0.02$. Dashed lines denote 95% confidence intervals.

counterparts of normal stature ($HAZ \geq -1$). Moreover, an association between abdominal fat with increased values of SBP was found among stunted individuals but not among those with normal stature.

The diagnosis and treatment of mild forms of undernourishment are crucial to minimise/prevent harmful consequences in later life. In view of the significant changes observed in mildly stunted youngsters, it is suggested that the cut-off points proposed by WHO in 2007 should be reevaluated.

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Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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