Original article

The Profile of BMI, visceral fat, and blood pressure between stunting and non-stunting in school-age children

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Abstract. *Background and Objectives:* Stunting is a prevalent type of malnutrition that frequently affects in school-age children. The prevalence of stunting among school-age children in Indonesia was 30.7% among children aged 5–12 and 35.1% among children aged 13–15. Early stunting is considered as a contributing factor for the development of overweight and adiposity in later stages of life. Rapid growth also provides adverse consequences for stunting children in long-term health, such as a higher risk of developing hypertension. This study is performed to determine the profile of BMI, visceral fat and blood pressure between stunting and non-stunting in school-age children. *Methods:* A case control study involving 191 children aged 8 years for the female and 9 years for the male. The subjects divided into two group according to HAZ status: stunting (HAZ score <–1.64) and non-stunting (HAZ score > 1.64). *Results:* Study groups consisted of stunting (98 subjects) and non-stunting group (93 subjects). Stunting children had significant higher BMI, BMI-for-age-z-score, waist circumference, visceral fat and total body fat, also less upper arm circumference, muscle mass, muscle quality, basal metabolic rate and bone mass compared to non-stunting children. Boys in non-stunting group showed significant higher body weight, body height and muscle mass. Stunting girls showed highest BMI and visceral fat. There was a significant association between HAZ score with BMI and visceral fat, but no association with blood pressure. *Conclusion:* Stunting children was correlated with higher profile of BMI and visceral fat but had no difference or correlation with both systolic and diastolic blood pressure. Overweight and obesity was more frequent in stunting girls. (www.actabiomedica.it)

Key words: Stunting, body mass index, obesity, visceral fat, blood pressure

Introduction

Indonesia is facing a triple burden of malnutrition: stunting, wasting, and obesity. Stunting is a prevalent type of malnutrition that frequently affects school-age children (1). Stunting children can be characterized as height-for-age z score (HAZ) less than -2 SD using WHO growth chart or under 5th percentile using CDC growth chart. Stunting and short stature are not the same; stunting is a sort of chronic malnutrition, but short stature can be caused by other systemic disorders such hormonal or genetic abnormalities (2). Indonesian Basic Health Survey in 2013, shows that the prevalence of stunting among school-age children in Indonesia was 30.7% (12.3% severe and 18.4% moderate) among children in the 5–12 age group, means that Indonesian children were 5-10 cm shorter than WHO standards, with deterioration in growth trajectories evident from early school age through older adolescence (3). This indicates that the incidence of stunting in children in Indonesia persists at a notable level and remains a serious public health concern in the country. The detrimental effects of both stunting and obesity on overall health are firmly established. Early stunting is considered as a contributing factor for the development of overweight and adiposity in later stages of life (4). Stunting children with excessive weight gain after the age of 2 years are more likely to develop overweight or obesity in the future. There is a possibility that linear growth loss that occurs during infancy, will not be fully recovered even with excessive of energy intake later on (5). If the amount of energy consumed is greater than the amount of energy expended, then weight gain may occur more frequently than length (6). A study found an association between early stunting and higher visceral fat accumulation in adulthood after adjustments for current BMI. As body fat increases, the inability of fat cells to form in the subcutaneous fat compartment may result in the accumulation of fat in other tissues, including visceral adipose tissue, pancreas, muscle, and liver. The surplus storage of fat in this context may lead to the unfavorable allocation of abdominal fat and hepatic steatosis, along with impaired insulin action that results in insulin resistance, glucose intolerance, and diabetes. Body's composition, specifically fat mass, is considered to have a substantial impact on both the development and outcomes of long-term stunting. Therefore, body composition assessment is currently being used as a standard measure for multiple clinical and nutrition-related studies (7). In addition, rapid growth involves the prioritization of energy allocation from nutrition intake towards catch-up growth, resulting in suboptimal development of metabolic organs and kidneys. Therefore, the rapid growth provides adverse consequences for an individual's long-term health, such as a higher risk of developing hypertension in the future (8). Another study conducted among Brazilians children, reports that increasing body mass index (BMI) is positively correlated with hypertension and stunting as a contributing factor. In those study, shows that a correlation between stunting and hypertension was more pronounced in women (38.5%) compared to men (18.4%) (9). The background narrative will provide the foundation for our study of the profile of BMI, visceral fat, and blood pressure between stunting and non-stunting school-age children.

Methods

Study design

A case-control study was performed start on October – November 2022. We recruited subjects who were studying in Public Elementary School in Surabaya, using consecutive sampling. In this study, we investigated the profile of BMI, visceral fat, systolic and diastolic blood pressure, in school-age children who experienced stunting and those who weren't. Stunting was defined as height-for-age WHO Z-score (HAZ) <−1.64 The non-stunting or control group included children with HAZ ≥ −1.64.

Samples

Samples recruitment of this research is stunting and non-stunting children with the minimum age of the subjects are 8 years for the girls and 9 years for the boys. Children with a syndrome which can impact growth, development, and puberty stages (Turner syndrome, Down syndrome, etc.) or had chronic diseases which can impact growth, development, and puberty stages (such as type 1 diabetes mellitus) were excluded. Subject does not participate in one or more examination processes for any reason or subjects refuse to continue the study, will be drop out from this study.

Sample size was measured with:

$$n=\frac{Z_{1\quad /5}^{2}P(1\quad \mathrm{P})}{\mathrm{d}^{2}}$$

Note:

n : sample number

P : subject proportion in the study = 0.5

d^2 : absolute value = 0.1

$Z_{1-\alpha/5}$: expected significant = 1.96
CI : Confidence interval = 95%
n = 97 subjects.

Measurements

Anthropometric measurements

Qualified health personnel performed the anthropometry measurements. Subjects were required to take off their shoes or socks and only wear minimum school uniform. Weight and body composition measurements were recorded using calibrated electronic scales, with the nearest 0.1 kg using calibrated electronic scales using dual frequency wireless body composition monitor (*Tanita RD 953*®). Height measurement was performed using a stadiometer with each measurement being made to the nearest 0.1 cm (*SECA 213 Stadiometer*®). Subject was instructed to stand straight with their heals, calves, buttocks, scapula, and the back of the head touching the vertical side of the stadiometer. The principles of TANITA recording the body composition by passing a small electrical current through the body and measuring the resistance (impedance) encountered when the subjects were standing upright on the scales (10,11), and focusing on the percentage and distribution of adipose tissue via high current source (50 kHz, 500μA) (11), and the usage of TANITA RD-953 still provides a reliable measurements, making it suitable for tracking changes over time (12). We realise that it was not a golden standard for recording body composition such as ultrasound. However, this method was the cheapest, easy to conduct in the population, and TANITA RD – 953 can be used to measure the body composition (13), even if the reliability is vary depend on the population (14). Other study using Tanita BC-420 for calculating BIA, and showed that BIA indicated moderate to good agreement for measuring body composition (15). BMI was calculated by dividing the subject's weight (in kg) by the square of the subject's height (in m^2). The Centers of Disease Control and Prevention (CDC) defines obesity as having a BMI higher than the 95^{th} percentile for a certain age and gender, and overweight as having a BMI between the 85^{th} and 95^{th} percentile (16). Subject's waist circumference (WC) and mid upper arm circumference (MUAC) was measured using a constant tension tape measure (*SECA 201*®). Subject's WC was recorded by setting a horizontal tape measure at approximate middle point between the lower edge of the last palpable rib and the top of the iliac crest. MUAC was measured by placed the tape around the straightened arm in the middle of the upper arm and also inspected to verify that it was neither excessively tight nor too loose. Subject's arm was requested to straightened. WC and MUAC was recorded to the nearest 0.1cm. Moreover, the waist-to-height ratio (WHtR) was calculated with Bjorntorp formula. Blood pressure was measured with Omron M6 electronic monitor (*Omron Healthcare*®), an adult or pediatric cuff was used as needed. Measurements complied with GOSH (*Great Ormond Street Hospital*) regulations (17). The child was seated with their legs uncrossed for at least one minute before their blood pressure was taken. The value that was recorded was the lowest.

Statistical analysis

For data analysis, we used IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp. Subject's data was assessed for homogeneity and normality test. Independent T-test was performed for normal data distribution and Mann-Whitney U-test was performed if the distribution was not normal. Fischer exact test was used for nominal variables, while Chi-Square test used for ordinal variables. The correlations between HAZ score with BMI, visceral fat, systolic and diastolic blood pressure were examined using the Spearman correlation test. Results determined as significant if P value <0.05.

Results

A total of 191 children, including 93 boys and 98 girls, were enrolled in this study. These subjects were divided into two groups: the stunting group which consisted of 98 children, and 93 children were in non-stunting group as the control group. The subject's birth history revealed that 12.19% of the subjects were preterm, while 87.80% were normal birth. No correlation was detected between stunted with gestational age (r=0.117, P=0.584). The prevalent of normal birth length (> 48 cm) was 80.68%, while idiopathic short stature (<48 cm) recorded were 19.32%, and no correlation between birth length categories (normal vs. idiopathic short stature) with HAZ categories (stunted vs. non-stunted), r=0.125, *P*=0.254. The subjects with normal mode of delivery were 79.71%, while Caesar delivery was 20.29%, and no correlation between mode of delivery with HAZ categories (r=0.127, *P*=0.187). Subject's characteristics were summarized in Table 1. There was no sex difference (*P*=0.248) between groups, also percentage proportion of boys (53.06% vs. 44.09%) and girls (46.94% vs. 55.91%) also almost the same. Mean age in stunting and non-stunting children also showed no difference (108.43 + 7.27 vs. 107.02 + 6.26, *P*=0.145).

As expected, stunting children had less body height, with significant higher BMI, BMI-for-age z-score, waist circumference, WHtR, visceral fat, total body fat. Those variables were the parameters to assess overweight/ obese, means that stunted children had higher overweight/obesity parameters such as BMI, waist circumference, WHtR, visceral fat and total body fat. While stunted children had a significant lower in mid upper arm circumference (MUAC, muscle mass, muscle quality, bone mass, and BMR. These findings indicating low quality of stunted children in upper lean mass, muscle mass, mascle quality and bone mass, while the body adapted with low intake by lowering BMR. However, no significant difference in body weight, WAZ, systolic blood pressure, diastolic blood pressure, and pulse between stunting and normal children's group.

Table 2 showed subject's characteristic based on gender. 52 boys and 46 girls were involved in stunting group, and 41 boys and 52 girls were in non-stunting group. There was an age difference between gender in both groups. Boys in non-stunting group were showed significant older age (*P*<0.0001), also higher body height (*P*=0.013) than other variable groups. Even though, girls in stunting group showed highest BMI (*P*=0.045), and visceral fat (*P*=0.052). There was no significant difference in body weight, mid upper arm circumference, HAZ, WAZ, BMI-for-age z-score, total body fat, muscle mass, muscle quality, bone mass, and basal metabolic rate between gender.

Table 3 was summarized the correlation between HAZ score HAZ-score with BMI, Visceral Fat and Systolic and Diastolic Blood Pressure. HAZ score had very weak negative correlation with body mass index (*r*=-0.234, *P*=0.001), also with visceral fat (r=-0.246, *P*<0.0001). There's no significant correlation between HAZ score with both systolic (r=0.047, *P*=0.521) and diastolic blood pressure. (r= -0.038, *P*=0.607). Scatter plot for correlation between HAZ-score with BMI, visceral fat, systolic and diastolic blood pressure were presented in Figure 1.

Discussion

This research documented that the stunting children had a correlation with higher BMI profile and had higher risk to become overweight or obesity. This result supports the concepts and hypotheses about excessive energy intake and linear growth loss in stunting children which we already described above. A prospective research by Grillo *et al* (18), that stunted children achieved weight gain 6 kg/year, while non-stunted children remained at 4 kg/year, even both groups had consumed similar diets. A nationwide survey from four large countries: Russia, China, South Africa and Brazil in 3–6 years and 7–10 years old children, noted that stunting children were likely to become overweight or have abdominal obesity because of higher exposed to energy-dense and high-fat foods along with moderate physical activity (19). Additionally, Li *et al*. revealed that children who were overweight and stunted, also consumed fewer fruits, vegetables, PUFA, protein, and iron (20). Therefore, this increased of accessibility and intake of high energy and high fat meals, combined with low physical activity, may further contribute to faster weight gain in stunting children. Stunting and obesity might coexist in such transitory societies. The cumulative impact of all factors above, increasing the risk of stunting children to likely be overweight, also develop in non-communicable diseases (21). The prevalence of overweight and obesity among stunting children in this study were 16.33% and 1.02%. These findings were lower than the Indonesia national data statistics in 2013, which revealed that 18.8% children between the ages of 5 and 12 were overweight and stunting, but higher with another recent multi-region research in Indonesia that involves 8,599 children aged

Table 1. Subject's characteristics

Characteristic	Stunting (n=98) Mean + SD	Non-stunting (n=93) Mean + SD	Total (n=191)	*P* value
Sex				
Boys, n (%) Girls, n (%)	52 (53.06%) 46 (46.94%)	41 (44.09%) 52 (55.91%)	93 (48.69%) 98 (51.31%)	0.312[a]
Age, month	108.43 ± 7.27	107.02 ± 6.26	107.74 ± 6.81	0.145[b]
Birth weight, kg	2.83 ± 0.49	2.96 ± 0.47	2.90 ± 0.48	0.088[c]
Birth length, cm	48.07 ± 5.89	48.88 ± 2.26	48.50 ± 4.33	0.283[c]
Body height, kg	120.53 ± 3.48	129.63 ± 6.07	124.96 ± 6.69	<0.0001[b]
Body weight, kg	26.37 ± 4.51	26.79 ± 5.11	26.57 ± 4.80	0.866[b]
BMI	18.23 ± 4.44	15.97 ± 2.30	17.44 ± 3.83	<0.0001[b]
Waist circumference, cm	63.51 ± 6.57	59.06 ± 6.18	61.34 ± 6.74	<0.0001[c]
WHtR	0.53 ± 0.06	0.46 ± 0.04	0.49 ± 0.06	<0.0001[c]
Mid upper arm circumference, cm	18.26 ± 1.90	21.54 ± 3.27	19.86 ± 3.12	<0.0001[b]
HAZ score	-2.05 ± 0.30	-0.42 ± 0.87	-1.26 ± 1.04	<0.0001[b]
WAZ score	-0.59 ± 1.07	-0.39 ± 1.23	-0.49 ± 1.09	0.189[c]
BMI-for-age z-score	0.70 ± 1.22	-0.28 ± 1.23	0.22 ± 1.32	<0.0001[c]
Visceral fat	1.80 ± 1.33	1.18 ± 0.39	1.50 ± 1.04	<0.0001[b]
Total body fat, percentage	19.32 ± 5.29	14.84 ± 9.29	17.14 ± 7.82	<0.0001[b]
Muscle mass	20.28 ± 4.35	23.96 ± 5.79	22.07 ± 5.41	<0.0001[b]
Muscle quality	58.41 ± 6.41	62.46 ± 8.19	60.38 ± 7.59	0.004[b]
Bone mass	0.85 ± 0.38	1.26 ± 0.42	1.05 ± 0.45	<0.0001[b]
BMR	628.58 ± 84.31	738.47 ± 140.42	682.37 ± 127.44	<0.0001[b]
SBP, mmHg	104.80 ± 8.48	103.52 ± 14.68	104.18 ± 11.86	0.912[b]
DBP, mmHg	70.37 ± 9.31	71.00 ± 9.29	70.68 ± 9.28	0.925[b]
Pulse, bpm	94.33 ± 16.07	94.17 ± 14.20	94.25 ± 15.15	0.883[b]

[a]Fischer's exact test; [b]Mann-Whitney U test; [c]Independen T test.

Abbreviation: BMI, body mass index; WHtR, waist circumference-to-height ratio; HAZ, height-for-age z-score; WAZ, weight-for-age z-score; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMR, basal metabolic rate.

8-12 years in 2019, reported that 7.5% of children with concurrent stunting and overweight (22). In comparison with other countries, the prevalence of overweight and stunting children in our study was higher, than studies conducted in oil-rich country, Kuwait that reported 1.18% from 172,573 school age-children was stunting overweight children (23), and in rural Mexico area which 10% among indigenous children and 5% among non-indigenous children from 7,555 pre-school aged children (24). This disparity may be caused by the distinctions between educational background and socioeconomic level (25). Children from lower socioeconomic backgrounds were more likely to experience both stunting and obesity at the same time (24). Mothers who attend with less of secondary education had also greater rates of associated overweight and stunting of her child (26). Additionally, we determined the prevalence of overweight and obesity was frequent in stunting girls, which were 21.74% and 2.17%. Meanwhile, only 11.53% stunting boys were overweight, and none of these stunting boys were obese. These results were in line with a study by

Table 2. Subject's Characteristic Based on Gender

Characteristic	Stunting (n=98) Mean + SD		Non-stunting (n=93) Mean + SD		*P*-value
	Boys (n=52)	Girls (n=46)	Boys (n=41)	Girls (n=52)	
Age, month	110.10 ± 7.33	106.54 ± 6.80	112.71 ± 3.22	102.54 ± 4.00	<0.0001[a]
Body height, kg	121.46 ± 3.42	119.48 ± 3.27	132.59 ± 6.29	127.30 ± 4.79	0.013[a]
Body weight, kg	26.05 ± 4.00	26.73± 5.05	27.87 ± 4.39	25.94 ± 5.50	0.062[a]
BMI	17.78 ± 2.35	20.03 ± 5.78	15.85 ± 1.83	16.06 ± 2.62	0.045[a]
Waist circumference, cm	61.72 ± 6.77	65.52 ± 5.76	57.96 ± 6.23	59.92 ± 6.06	0.311[a]
WHtR	0.51 ± 0.05	0.55 ± 0.05	0.44 ± 0.04	0.47 ± 0.04	0.490[a]
Mid upper arm circumference, cm	18.33 ± 1.89	18.19 ± 1.93	22.66 ± 3.66	20.66 ± 2.64	0.013[a]
HAZ score	-2.03± 0.30	-2.08 ± 0.30	-0.36 ± 0.95	-0.47± 0.81	0.766[a]
WAZ score	-0.74 ± 0.86	-0.44 ± 1.24	-0.39 ± 1.00	-0.39 ± 1.22	0.344[a]
BMI-for-age z-score	0.58 ± 1.06	0.84 ± 1.38	-0.37 ± 1.09	-0.21 ± 1.34	0.785[a]
Visceral fat	1.48 ± 0.66	2.02 ± 1.76	1.10 ± 0.28	1.24 ± 0.46	0.052[a]
Total body fat, percentage	18.41 ± 3.71	20.34 ± 6.53	12.04 ± 12.00	17.05 ± 5.62	0.150[a]
Muscle mass	21.25 ± 3.36	19.09 ± 5.03	26.68 ± 7.12	21.82 ± 3.16	0.060[a]
Muscle quality	58.98 ± 6.11	57.76 ± 6.74	62.90 ± 8.63	62.16 ± 7.90	0.840[a]
Bone mass	1.05± 0.36	0.61 ± 0.25	1.48 ± 0.32	1.09 ± 0.43	0.549[a]
Basal metabolic rate	658.78 ± 101.61	595.10 ± 94.64	789.78 ± 164.22	698.02 ± 103.10	0.377[a]
SBP, mmHg	106.17 ± 7.98	103.07 ± 8.82	106.75 ± 10.31	101.13 ± 17.05	0.465[a]
DBP, mmHg	70.58 ± 10.04	70.13 ± 8.40	70.68 ± 11.01	71.27 ± 7.88	0.702[a]
Pulse, bpm	92.52 ± 14.79	96.57 ± 17.20	89.50 ± 15.09	97.67 ± 12.55	0.347[a]

[a]Two Way Anova

Abbreviations: BMI, body mass index; HAZ, height-for-age z-score; WHtR, waist-to-height ratio; WAZ, weight-for-age z-score; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 3. Correlation between HAZ-score with BMI, Visceral Fat and Systolic and Diastolic Blood Pressure

Variable	BMI[1]		Visceral Fat[1]		Systolic BP[1]		Diastolic BP[1]	
HAZ	r	*P*	r	*P*	r	*P*	r	*P*
	-0.234	0.001	-0.246	<0.001	0.047	0.521	-0.038	0.607

[1]Spearman Rho.
Abbreviation: HAZ, height-for-age z-score; BMI, body mass index; BP, blood pressure.

Sawaya et al. (27), which reported stunting girls gained greater weight, also a favorable correlation between baseline fat consumption and weight-for-height gain in marginally stunting girls after 22 months. According to some studies conducted in South African (21,28) and Tanzania (29), girls indeed likely to develop overweight or obese than the boys. These sex disparities could be explained by multiple factors: (a) Boys and girls have different biological energy requirements depending on growth movement as well.

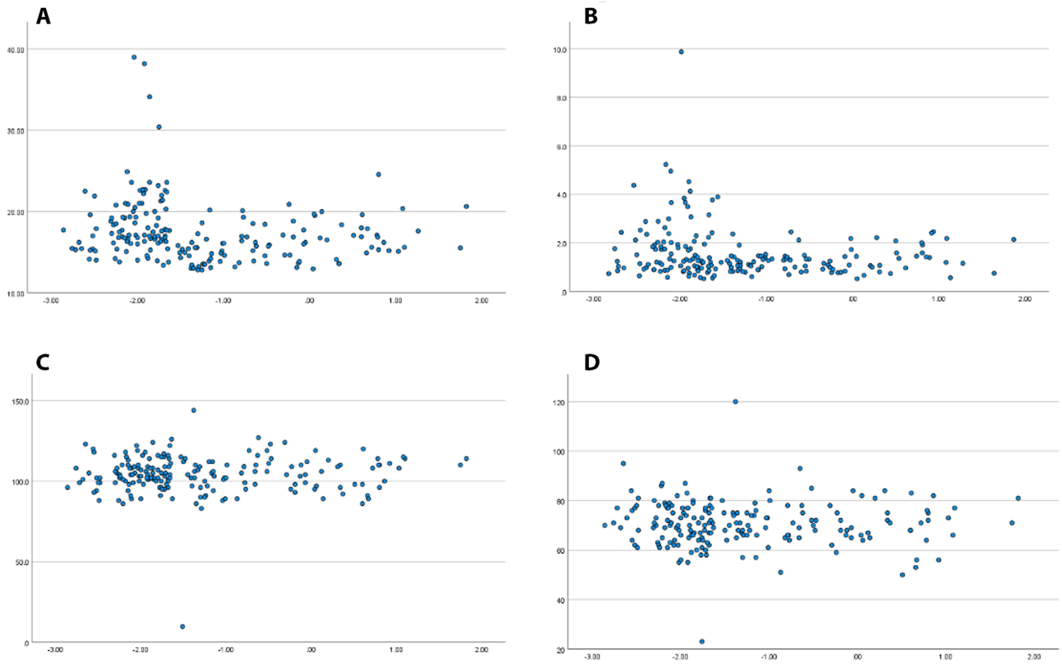

Figure 1. Graphs demonstrating the scatter plots between the HAZ score and (a) BMI, (b) visceral fat, (c) systolic blood pressure, and (d) diastolic blood pressure

Also, the timing of sexual maturity varies depending on the sex (29), (b) Boys often more physically active than girls (25), and (c) Unhealthy eating habits in such irregular meal schedules in girls, which can accelerate weight gain (30). Prior studies had already reported that stunting children had higher total body fat percentage (BF%) than non-stunting children (4,21,38,39,25,31–37), which in line with our results. Hoffman et al.'s (40) explained that stunted children had a lower resting energy consumption than those who were not. Stunted children had a higher respiratory quotient and carbohydrate oxidation, but less fat oxidation, suggesting that stunted children was more susceptible to develop body fat. Moreover, children with undernutrition who experienced catch-up growth increases metabolic efficiency, also resulting in energy conservation and more fat accumulation. This inclination is termed as "post-starvation obesity" or "metabolic adaptation" (41). In addition, Sawaya *et al.* (27) suggested that long-term malnutrition may be associated with decreased levels of insulin-like growth factor-1 in the bloodstream. The decreased of insulin-like growth factor-1 levels was correlate with lower insulin levels and greater cortisol-to-insulin ratios, which were linked to central fat formation. We noted this finding as the subjects were at preadolescents period that need a comprehensive management preventing the triple burden of malnutrition pandemic in the future as the consequences of inappropriate nutritional intake and unhealthy habits along with "rebound adiposity". In fat distribution, stunting children had reported more likely to accumulate abdominal fat (37,42,43). The quantitative measures of abdominal obesity contain of some measurements such as: visceral fat, waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) (44) reliable with our study, which results stunting children had higher WC, WHtR and visceral fat than non-stunting children. Visceral fat has been shown to be a more reliable and persistent to diagnose abdominal obesity (45,46) and it is the gold standard for the diagnosis of abdominal obesity (47). Additionally, there is strong evidence that higher visceral fat area was associated to metabolic syndrome (MetS) (48), cardiovascular disease (49,50), and type 2 diabetes mellitus (51). Although, somehow studies which relating visceral fat to stunting children were still limited, we found an earliest study conducted in Pelotas, a Southern Brazil city that after correcting for present BMI, discovered a correlation between prior stunting and increased visceral fat accumulation in maturity (7). Even, in those study, visceral fat was measured using abdominal ultrasound, which may be less comparable to our methods which used dual frequency *BIA* body composition scales. We had not found any studies that associate visceral fat with stunting children using dual frequency *BIA* body composition as ours. Contrast with fat mass, stunting children was found less muscle mass, muscle quality, also mid upper arm circumference (35,38,52). Mid-upper arm muscle circumference reported had a high correlation with DXA-measured lean body mass (53). This less muscle mass in stunting children, due to insufficient energy intake, so there was a tendency to use up protein stores in their muscles as a source of energy (54). Muscle tissue catabolism also increases significantly during protein-energy deficiency, resulting in a loss in muscle mass in those individuals (55). Loss of or a reduction in lean mass may be a major factor in changing glucose homeostasis, including metabolic dysregulation of insulin-stimulated glucose uptake, and may have a role in the development of metabolic diseases in later life (56). Lower lean body mass, also resulting lowers their basal metabolic rate and level of physical activity (19). A 36-months longitudinal study enrolled in Brazil, which include stunted girls aged 7 to 11 years discovered that stunted children had a decreased resting metabolic rate across the follow-up period, with significant differences between the 24-month and 36-month periods (18). Even our result showed a correlation in HAZ score with BMI and visceral fat in stunting children, but we found no significant difference and correlation with systolic and diastolic blood pressure. In line with study by Van Royeen *et al* (57), which discovered that there's no differences in systolic and diastolic blood pressure between stunting and non-stunting children aged 10-15 years, even after adjusting the BMI and pulse rate. But, in those study also revealed that stunted children had significantly higher total peripheral resistance and reduced stroke volume, arterial compliance, and cardiac output. Therefore, we may presume that there are circulatory abnormalities in stunted children, even the results showed no exhibit differences in blood pressure from non-stunted children. Furthermore, it is necessary to carry out further follow-up research and perhaps consider other measurement devices to assess cardiovascular changes in stunting children. Additionally, we also found in stunting children had low value of bone mass than in normal children. A study conducted in Egypt, which include 4002 adolescents aged 10–18 years reported that stunted adolescents showed low level of bone mineral density (BMD) (58). Furthermore, high BMI was also reported as independent predictor of low BMD in children (58,59). There were some limitations to our study: a universality sample because all of the children were from settlements in the Surabaya area. Rural areas or student populations with higher incomes may present a different result; the validity of utilizing the dual frequency BIA values generated by the Tanita monitor which not a gold standard for examined body composition; also, there was no further follow-up to assess progress in the subjects' metabolism and cardiovascular systems. Further study is needed to identify the development of metabolic and cardiovascular abnormalities in stunting children due to the probability of hormonal and metabolic differences while maturing, also consider golden standard measurements for better outcomes. Therefore, it's expected that the subsequent exam's findings will be more precise.

Conclusion

Stunting children was correlated with higher profile of BMI and visceral fat but had no difference or correlation with both systolic and diastolic blood pressure. Overweight and obesity was more frequent in stunting girls. Comprehensive planning and nutritional programs were expected, to reduced stunting rates, also the complications.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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