OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2019.

Research Article
Body Composition of Adolescent of Shorter Stature

[1]Adhila Fayasari, [2]Emy Huriyati and [3]Madarina Julia

[1]Department of Nutrition, Faculty of Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2]Department of Nutrition and Health, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia
[3]Division of Paediatric Endocrinology, Department of Child Health, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Dr. Sardjito Hospital,Yogyakarta, Indonesia

Abstract
Background and Objective Studies have shown that adults with stunted growth have a higher risk of obesity and higher fat mass. This study aimed to assess whether stature was associated with risk of obesity and adverse body fat composition in Indonesian adolescents. **Materials and Methods:** This study used a cross-sectional study and included 730 adolescents aged 15-18 years in Yogyakarta, Indonesia. Data on height and body mass index (BMI) were converted to height-for-age standard deviation scores (SDS) and BMI-for-age SDS, based on the World Health Organizations (WHO) 2007 guidelines. Body fat percentage was measured with the Full Body Sensor Body Composition Monitor and Scale (Omron HBF 516, Japan), which estimated body fat percentage using Bioelectrical Impedance Analyses. Individuals were designated as shorter or taller using median height-for-age SDS with a cut-off of 1.0. BMI-for-age SD, waist circumference, waist-to-height ratio and body fat percentage were compared using t-tests. **Results:** There was no difference in the odds for obesity between shorter and taller adolescents. While taller adolescents had large waist circumferences, after controlling for height, shorter female adolescents had larger waist-to-height ratios. Differences in body fat percentage were not consistent across gender and nutritional status. **Conclusion:** There was no difference in the odds for obesity between shorter and taller adolescents. However, after controlling for height, shorter adolescents had larger waist-to-height ratios.

Key words: Short stature, stunted growth, body mass index, waist circumference, waist-to-height ratio, body fat, adolescents, Indonesia

Received: Accepted: Published:

Citation: Adhila Fayasari, Madarina Julia and Emy Huriyati, 2019. Body composition of adolescent of shorter stature. Pak. J. Nutr., CC: CC-CC.

Corresponding Author: Adhila Fayasari, Department of Nutrition and Health, Faculty of Medicine, Universitas GadjahMada, Jl. Farmako, Sekip, Yogyakarta, 55281, Indonesia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Several studies in adults have found an association between stunted growth or short stature with an increased risk for obesity or adiposity, insulin resistance, type 2 diabetes mellitus and other features of metabolic syndrome[1,2]. In addition, short adults have lower energy expenditure that puts them at higher risk of weight gain; this relationship has been linked to sub-optimal growth early in life[3]. Intrauterine growth retardation and malnutrition early in life are also associated with lower lean body mass, which increases risk of adiposity later in life[4].

In contrast to studies in adults, research in children and adolescents has revealed conflicting results. A study in Germany found an inverse relationship between short stature and obesity, such that taller children were at greater risk of obesity[2]. However, a study in Brazil showed the opposite findings in adults, in which shorter adolescents had an increased risk for the accumulation of abdominal fat[5]. In South Africa, one study found no association between stunted growth and any parameter of body fatness in adolescents; however, this study observed that older adolescents with stunted growth tended to gain fat faster than their non-stunted peers[6].

Most previous studies have been performed in people of Caucasian or African origin. Compared to Caucasians, Asian people are more likely have higher abdominal fat based on body composition[7,8]. In addition, East Asian people tended to be shorter than Caucasians[9]. Therefore, this study aimed to assess whether stature is associated with risk of obesity or adverse body fat composition in Indonesian adolescents.

MATERIALS AND METHODS

Participants: Participants were 15-18-year-old students from the 10 public senior high schools in Yogyakarta, Indonesia. Sample size was estimated using Open-Epi (www.openepi.com). With a population of 5,261 students, the estimated proportion of obesity in short adolescents was 4.2% with a confidence level of 95%; therefore, the minimum sample size was 361[6]. Since a cluster sampling method was used, minimal sample size was doubled from the original estimation to account for the design effect, resulting in a minimal sample size of 721. There were approximately 25 students in a classroom. To include at least 721 students, we randomly selected 29 classrooms as clusters from the available 156 classrooms (i.e., approximately 2-4 classrooms per high school).

This study was approved by the Medical and Health Research Ethics Committee, Faculty of Medicine/Sardjito Hospital, Gadjah Mada University. Written informed consent was obtained from the participants' parents or legal guardians, as well as the adolescent.

Data collection: Three trained nutritionists measured weight, height, waist circumference and body fat percentage. One nutritionist measured height, one measured waist circumference and one measured weight and body fat percentage. All measurements were performed in duplicate; the average of the two measurements was used for further analyses. Measurements were taken in the morning, between 9 and 11 am, with children dressed in light school uniforms without shoes.

Height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Germany). Body weight was measured to the nearest 0.1 kg using a digital scale (Omron HBF 516, Japan). Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m^2). Data on height and BMI were converted into age and gender-specific height-for-age standard deviation scores (SDS). BMI-for-age SDS was based on the World Health Organization (WHO)[10] growth reference guidelines.

Waist circumference (WC) was measured in the middle of the 10th rib and the iliac crest to the nearest 0.1 cm. Participants were measured standing at the end of a normal expiration using a non-elastic, flexible body circumference measuring tape (Seca 201, Germany). Data on waist circumference are presented as waist circumference (WC) and waist-to-height ratio (WHtR).

Body fat percentage was measured using the Full Body Sensor Body Composition Monitor and Scale (Omron HBF 516, Japan), which estimates body fat percentage by Bioelectrical Impedance Analyses (BIA)[11]. To enhance the accuracy of the measurements, participants were requested to limit ingesting meals and large amounts of water, in addition to withhold moderate or vigorous physical activity (2-3 h) before the measurements[11,12]. Participants with medical conditions that could influence their body water composition like edema or those with a cardiac pace maker or history of arrhythmia (which could cause safety issues during measurements) were excluded[12].

Statistical analyses: The odds for obesity in adolescents were analysed using chi-square tests. Differences in waist circumference, waist-to-height ratio and body fat percentage, either stratified by gender alone or by gender and nutritional status, were compared using t-tests at a 0.05-significance level.

RESULTS

Out of the 882 students in the selected classrooms, 730 (83%) students (female: 435 (59.6%), male: 295 (40.4%) were included in the study. Mean (SD) of gender-specific height-for-age SDS and BMI-for-age SDS were -0.97 (0.82) and -0.09 (1.25), respectively.

The total mean (SD) percentage of body fat was 21.0 (7.5)% (female: 25.6 (4.2%), male: 14.3 (6.2%)). As female adolescents had a significantly higher percentage of body fat, with a mean difference of 11.3 [95% confidence interval (CI): 10.5-12.0] (p<0.001), further analyses were stratified by gender. Table 1 shows a comparison of BMI-for-age SDS, WC, WHtR and body fat percentage of adolescents stratified by gender using median height-for-age SDS with a cut-off of 1.0.

The prevalence of wasting (BMI-for-age SDS <-2.0), normal weight (BMI-for-age SDS ≥-2.0 and <1.0), overweight (BMI-for-age SDS ≥1.0 and <2.0) and obesity (BMI-for-age SDS ≥2.0) were 4.2, 76.3, 13.2 and 6.3%, respectively. There was no difference in the odds for wasting or obesity between shorter and taller adolescents, odds ratio (OR) of 1.0 (0.5-0.1) (p = 0.99) and 1.3 (0.9-1.9) (p = 0.13), respectively. Table 2 shows a comparison of WC, WHtR and body fat percentage of adolescents stratified by gender and nutritional status.

DISCUSSION

The median height of the adolescents in this study was one standard deviation below average based on the WHO 2007 guidelines[10]. Therefore, it was difficult to determine whether their short stature was caused by sub-optimal growth early in life or if their stature was genetically determined. Participants of the present study were public high school students from an urban area. However, it has been reported that Asian people, especially those of East Asian origin, are shorter than the WHO average, irrespective of socioeconomic status[9].

Associations between shorter stature and higher risk for various aspects of the metabolic syndrome may be caused by sub-optimal intrauterine growth or sub-optimal growth early in life. Regardless of cause, the association between shorter stature and higher risk for obesity, visceral adiposity and other components of the metabolic syndrome should be further studied[3,4].

Our study did not find any difference in risk of obesity based on height. We observed that taller adolescents had larger waist circumferences; however, when waist circumference was controlled for, shorter adolescents were found to have larger waists. Recent studies have found that, together with BMI, lean body mass and skinfold thickness, both waist circumference and WHtR are significant predictors of cardiovascular risk[13,14].

We did not observe differences in the percentage of body fat between taller and shorter participants. However, lean body mass measurements of these participants could predict cardiovascular risk and should be further studied[14].

Table 1: BMI-for-age standard deviation score, waist circumference, waist-to-height ratio and body fat composition across male and female adolescents

	Female adolescents*			
	Mean (SD)			
Variables	Shorter (n = 234)	Taller (n = 201)	Mean difference (95% CI)	p-value
BMI-for-age SDS	-0.03 (1.17)	0.02 (1.16)	-0.05 (-0.27-0.17)	0.64
Waist circumference (cm)	67.50 (8.3)	69.50 (8.9)	-2.00 (-3.7- -0.4)	0.01
Waist-to-height ratio	0.44 (0.05)	0.43 (0.05)	0.01 (0.001-0.21)	0.03
Body fat (%)	25.60 (4.1)	25.60 (4.2)	0.03 (-0.8-0.8)	0.94
	Male adolescents*			
	Mean (SD)			
Variables	Shorter (n = 163)	Taller (n = 132)	Mean difference (95% CI)	p-value
BMI-for-age SDS	-0.37 (1.26)	-0.08 (1.43)	-0.300 (-0.61- -0.01)	0.060
Waist circumference (cm)	70.60 (9.0)	74.10 (10.6)	-3.500 (-5.8- -1.2)	0.003
Waist-to-height ratio	0.44 (0.05)	0.43 (0.06)	0.004 (-0.009-0.02)	0.550
Body fat (%)	13.90 (5.6)	14.60 (6.7)	-0.670 (-2.11-0.77)	0.360

*Shorter: Below or at median height-for-age SDS based on WHO growth reference 2007 (≤-1.0), Taller: Above median height-for-age SDS (>-1.0) BMI: Body mass index, CI: Confidence interval; SDS: Standard deviation score, WHO: World health organization

Table 2: Waist circumference, waist-to-height ratio and body fat composition of shorter vs. taller across male and female adolescents based on nutritional status

Female adolescents*†	Wasting	Normal	Overweight	Obese
Mean (SD) waist circumference (cm)				
Shorter	57.9 (3.2)	65.0 (4.8)	75.6 (3.5)	90.3 (11.1)
Taller	58.6 (3.2)	66.8 (6.8)	78.7 (5.0)	88.2 (4.2)
Mean difference (95%CI)	-0.76 (-4.47-2.95)	0.63 (-3.04- -0.6)§	-3.22 (-5.35- -1.09)§	2.13 (-6.58-10.84)
Mean (SD) waist-to-height ratio				
Shorter	0.38 (0.02)	0.43 (0.03)	0.50 (0.02)	0.59 (0.07)
Taller	0.37 (0.02)	0.42 (0.04)	0.49 (0.03)	0.54 (0.03)
Mean difference (95%CI)	0.012 (-0.10-0.034)	0.01 (0.005-0.02)§	0.004 (-0.008-0.18)	0.04 (-0.01-0.10)
Mean (SD) body fat (%)				
Shorter	18.9 (3.3)	24.7 (2.7)	29.4 (3.7)	34.4 (5.9)
Taller	18.3 (2.4)	24.3 (2.9)	30.6 (2.5)	33.9 (1.1)
Mean difference (95%CI)	0.66 (-2.72-4.04)	0.39 (-0.20-0.99)	0.76 (-2.77-0.27)	0.48 (-4.00-4.96)
Male adolescents*†				
Mean (SD) waist circumference (cm)				
Shorter	59.3 (2.6)	68.8 (5.9)	81.3 (6.3)	94.4 (4.9)
Taller	62.7 (2.3)	70.1 (5.2)	84.1 (4.3)	95.0 (9.1)
Mean difference (95%CI)	-3.36 (-5.96- -0.77)‡	-1.33 (-2.79- 0.13)	-2.84 (-6.91-1.22)	-0.67 (-8.72-7.38)
Mean (SD) waist-to-height ratio				
Shorter	0.37 (0.02)	0.42 (0.03)	0.50 (0.02)	0.58 (0.03)
Taller	0.37 (0.01)	0.40 (0.03)	0.49 (0.02)	0.55 (0.04)
Mean difference (95%CI)	0.002 (-0.01-0.02)	0.02 (0.007-0.02)§	0.01 (-0.005-0.03)	0.02 (-0.02-0.06)
Mean (SD) body fat (%)				
Shorter	10.4 (2.4)	12.9 (4.4)	21.5 (3.5)	25.1 (1.34)
Taller	7.6 (1.0)	12.2 (4.1)	21.0 (2.6)	27.0 (5.01)
Mean difference (95%CI)	2.77 (0.84-4.69)§	0.37 (-0.75-1.50)	0.40 (-1.94-2.75)	-1.88 (-6.21-2.45)

*Shorter: Below or at median height-for-age SDS based on WHO growth reference 2007 (≤-1.0), Taller: Above median height-for-age SDS (>-1.0), †Wasting: BMI-for-age SDS <-2.0, Normal weight: BMI-for-age SDS ≥-2.0 and <1.0, Overweight: BMI-for-age SDS ≥1.0 and <2.0, Obese: BMI-for-age, SDS ≥2.0, ‡p<0.05, §p<0.001, BMI: Body mass index, CI: Confidence interval, SDS: Standard deviation score, WHO: World health organization

CONCLUSION

There was no difference in the odds for wasting or overweight/obesity between shorter and taller adolescents. Taller adolescents had larger waist circumferences but shorter adolescents to had larger waist-to-height ratios after controlling for height. There was no significant difference in body fat proportion between taller and shorter participants.

REFERENCES

1. Asao, K., W.L. Kao, K. Baptiste-Roberts, K. Bandeen-Roche, T.P. Erlinger and F.L. Brancati, 2006. Short stature and the risk of adiposity, insulin resistance and type 2 diabetes in middle age: The third national health and nutrition examination survey (NHANES III), 1988-1994. Diabetes Care, 29: 1632-1637.
2. Bosy-Westphal, A., S. Plachta-Danielzik, R.P. Dorhofer and M.J. Muller, 2009. Short stature and obesity: Positive association in adults but inverse association in children and adolescents. Br. J. Nutr., 102: 453-461.
3. Albuquerque, F.C.A., N.B. Bueno, A.P.G. Clemente, E. Ferriolli, T.M.M.T. Florencio, D. Hoffman and A.L. Sawaya, 2015. Association between adult stature and energy expenditure in low-income women from Northeastern Brazil. PLoS ONE, Vol. 10. 10.1371/journal.pone.0131891
4. De Franca, G.V.A., M.C. Restrepo-Mendez, C.L. de Mola and C.G. Victora, 2014. Size at birth and abdominal adiposity in adults: A systematic review and meta-analysis. Obes. Rev., 15: 77-91.
5. Da Luz Santos, C.D., A.P.G. Clemente, V.J.B. Martins, M.P. Albuquerque and A.L. Sawaya, 2010. Adolescents with mild stunting show alterations in glucose and insulin metabolism. J. Nutr. Metab., Vol. 2010. 10.1155/2010/943070
6. Mukuddem-Petersen, J. and H.S. Kruger, 2004. Association between stunting and overweight among 10-15-y-old children in the North West province of South Africa: The THUSA BANA study. Int. J. Obesity, 28: 842-851.
7. Wulan, S.N., K.R. Westerterp and G. Plasqui, 2010. Ethnic differences in body composition and the associated metabolic profile: A comparative study between Asians and Caucasians. Maturitas, 65: 315-319.
8. Rush, E.C., I. Freitas and L.D. Plank, 2009. Body size, body composition and fat distribution: Comparative analysis of European, Maori, Pacific Island and Asian Indian adults. Br. J. Nutr., 102: 632-641.

9. Hermanussen, M., K. Stec, C. Aßmann, C. Meigen and S. van Buuren, 2016. Synthetic growth reference charts. Am. J. Hum. Biol., 28: 98-111.
10. WHO., 2007. Growth reference 5-19 years. World Health Organization, Geneva, Switzerland.
11. Wang, J.G., Y. Zhang, H.E. Chen, Y. Li and X.G. Cheng *et al*., 2013. Comparison of two bioelectrical impedance analysis devices with dual energy X-ray absorptiometry and magnetic resonance imaging in the estimation of body composition. J. Strength Conditioning Res., 27: 236-243.
12. Demura, S. and S. Sato, 2015. Comparisons of accuracy of estimating percent body fat by four bioelectrical impedance devices with different frequency and induction system of electrical current. J. Sports Med. Phys. Fitness, 55: 68-75.
13. Mushtaq, M.U., S. Gull, H.M. Abdullah, U. Shahid, M.A. Shad and J. Akram, 2011. Waist circumference, waist-hip ratio and waist-height ratio percentiles and central obesity among Pakistani children aged five to twelve years. BMC Pediatr., Vol. 11. 10.1186/1471-2431-11-105
14. Gracia-Marco, L., L.A. Moreno, J.R. Ruiz, F.B. Ortega and A.C.F. de Moraes *et al*., 2016. Body composition indices and single and clustered cardiovascular disease risk factors in adolescents: Providing clinical-based cut-points. Progr. Cardiovasc. Dis., 58: 555-564.
15. Dehghan, M. and A.T. Merchant, 2008. Is bioelectrical impedance accurate for use in large epidemiological studies? Nutr. J., Vol. 7. 10.1186/1475-2891-7-26.