

Tri-ponderal mass index and body mass index for estimating body fat in children in Surakarta, Indonesia

Annang Giri Moelyo¹, Azzahra Fadhlila Aulia Nisa¹, Anita Sefti Astuti¹, Putri Ma'rifatul Mardiyah¹, Nur Fatimah Nikmatullah Azzainabi¹, Soebhita Hema Kumala¹, Cynthia Octaviani Rahayu¹, Lyviana Patrishia Purnata¹, Stefany Marcellia¹, Steiner Lukas Prisola¹

¹Department of Child Health, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

ABSTRACT

Background: The body mass index parameter is currently used to determine obesity (excess body fat) in children. Using this measure has limitations in predicting body fat, particularly in adolescents. An alternative parameter to predict body fat is the triponderal mass index (TMI). **Objective:** The study aims to investigate the different patterns between body mass index and triponderal mass index in children and to determine the correlation of body mass index (BMI) or TMI as a predictor of body fat. **Methods:** This was a cross-sectional study of 351 subjects aged 6-18 years in Surakarta (241 females; 110 males). All subjects underwent anthropometric measurements (height and weight) and body fat percentage measurements. We used equations for predicting the percent body fat in boys and girls based on their TMI and BMI. **Results:** TMI and BMI overall means were 13.3 ± 2.9 vs 20.2 ± 4.7 . Among subjects less and more than 12 years, the TMI and BMI means were 13.32 ± 1 vs 17.9 ± 3.6 , and 13.3 ± 3.1 vs 20.7 ± 4.8 . The adjusted R^2 of equations for predicting percent body fat based TMI and BMI were 0.76 vs 0.33 in boys and 0.89 vs 0.87 in girls). **Conclusions:** TMI showed greater stability with age than BMI. TMI was a better predictor for body fat percentage than BMI for both sexes, especially in boys. It is worth considering replacing body mass index with triponderal mass index to estimate body fat percentage in boys.

KEYWORDS: body fat; body mass index; children; tri-ponderal mass index

INTRODUCTION

Body mass index (BMI) is a simple and affordable tools of body fat percentage. The BMI is solely dependent on height and weight. Body mass index correlates with body fat, therefore, BMI is a useful measure for screening for obesity and its health risks [1]. Although widely used, BMI have some limitations, e.g. it may not apply equally to all genders, races, ethnicities, and ages; and its limitations to predict body fat percentage in adolescent [2,3].

Other body fat measurements, such as skinfold thickness, bioelectrical impedance, underwater weighing,

and dual-energy x-ray absorption, may be more accurate than BMI. Although this measure can provide a better indication of body fatness, they can be expensive, impractical, not commonly available, and difficult for observers or machines to standardize. Waist circumference or waist-to-height ratio is another simple measure of fat distribution [1].

The triponderal mass index (TMI), calculated as weight (kg)/height(m³), is an alternative indicator that has been proposed to predict body fat percentage and metabolic syndrome at least as well as or better than BMI. The impact of height power on the measurement

Corresponding author: Annang Giri Moelyo, Department of Child Health, Faculty of Medicine, Universitas Sebelas Maret, Jl. Ir. Sutami 36A Surakarta, Jawa Tengah 57126, Indonesia, e-mail: annanggm73@gmail.com

How to cite: Moelyo AN, Nisa AFA, Astuti AS, Mardiyah PM, Azzainabi NFN, Kumala SH, Rahayu CO, Purnata LP, Marcellia S, Prisola SL. Tri-ponderal mass index and body mass index for estimating body fat in children in Surakarta, Indonesia. *Jurnal Gizi Klinik Indonesia*. 2022;18(4):152-156. doi: 10.22146/ijcn.91159

was lessened by the “3” indice in TMI equation compare the “2” indice in BMI equation. Adolescent body fat percentage is influenced by height: obese children reach puberty earlier and hence taller than non-obese ones. Previous study revealed four advantages when using TMI than BMI: the stability with age, ability to estimate body fat percentage across the whole spectrum of adiposity, reduced the misclassification rate, and its simplicity (without calculation of the z-score as BMI) [4]. The prevalence of overweight and obesity in children and adolescents aged 6-17 years was higher when identified with BMI than with TMI. It was also noticed that metabolic syndrome in adolescents aged 10-17 years was better predicted by TMI than BMI (BMI z-score) [5]. A recent research suggests that TMI appears to be stable during adolescence. It can assess body fat percentage more precisely than BMI, especially in children and adolescents. It has been reported to have a better predictor of cardiometabolic risk than BMI [6]. Our objective was to compare the different patterns between BMI and TMI in children and adolescent, and to find the correlation between BMI or TMI as a predictor of body fat in children aged 6-18 years old in Surakarta.

METHODS

Study design and participants

We pooled data from two cross-sectional studies conducted from 2020 to 2021 on the school-age children (aged 6-18) residing in one junior high school and several orphanages in Surakarta. A healthy subject was included. We excluded children with a history of chronic disease, physical disabilities, and children did not consent to

participate in these studies. The ethics approvals were 1001/VIII/HREC/2020 and 553/V/HREC/2021 from Health Research Ethic Committee, Moewardi Hospital Surakarta.

Measures

All subjects underwent anthropometric measurements (height and body weight) using a wall stadiometer (Sature Meter 2M GEA) to the nearest 0.1 cm with the subject facing the examiner. Body weight was measured using a digital scale (Seca Clara 803, Germany) to the nearest 0.1 kg. Body fat percentages were measured by Bioelectrical Impedance Body Composition Monitor Omron HBF-212. Body mass index was a subjects’ weight divided by the square of height (kg/m²). Triponderal mass index was calculated as the weight divided by the height in metres cubed (kg/m³).

Data analysis

Means, standard deviations (SD) and percentages for descriptive data were given. We extrapolated the formula for BMI and TMI by quadratic local polynomial regressions analysis in STATA MP version 14.0 software. We hypothesized that the TMI is a more precise estimate of body fat percentage than BMI in children aged 6 to 18 years.

RESULTS

Table 1 provide a summary of the characteristics of the 351 subjects who were enrolled in this study. There were 296 subjects over the age of 12 and 55 subjects under that age. Most of them (246 subjects), were between the

Table 1. Baseline characteristics of subjects

	Girls (n=241)	Boys (n=110)	Total (n=351)	p-value*
Age (years, SD)	14.12 (1.52)	13.08 (2.86)	13.80 (2.09)	<0.001
Age (median, IQR)	14.00 (14.00-15.00)	14.00 (11.00-15.00)	14.00 (13.00-15.00)	0.011
BMI (kg/m ² , SD)	20.40 (4.85)	19.85 (4.36)	20.23 (4.71)	0.300
BMI (median, IQR)	19.3 (17.0-22.6)	19 (16.8-21.6)	19.2 (17-22.4)	0.480
TMI (kg/m ³ , SD)	13.37 (3.15)	13.25 (2.44)	13.33 (2.94)	0.720
TMI (median, IQR)	12.57 (11.13-14.96)	12.86 (11.57-14.26)	12.67 (11.31-14.66)	0.680
Body fat percentage(%)	26.18 (7.63)	19.77 (6.54)	24.17 (7.88)	<0.001

*unpaired t-test analysis; SD=standard deviation; IQR= interquartile range; BMI=body mass index; TMI=triponderal mass index

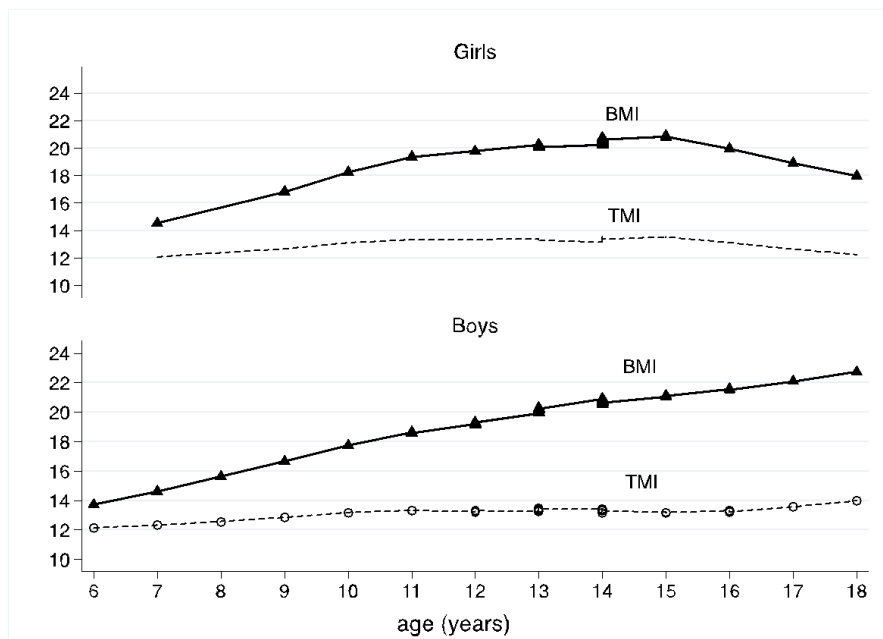


Figure 1. Body mass index (BMI) and triponderal mass index (TMI) of subjects

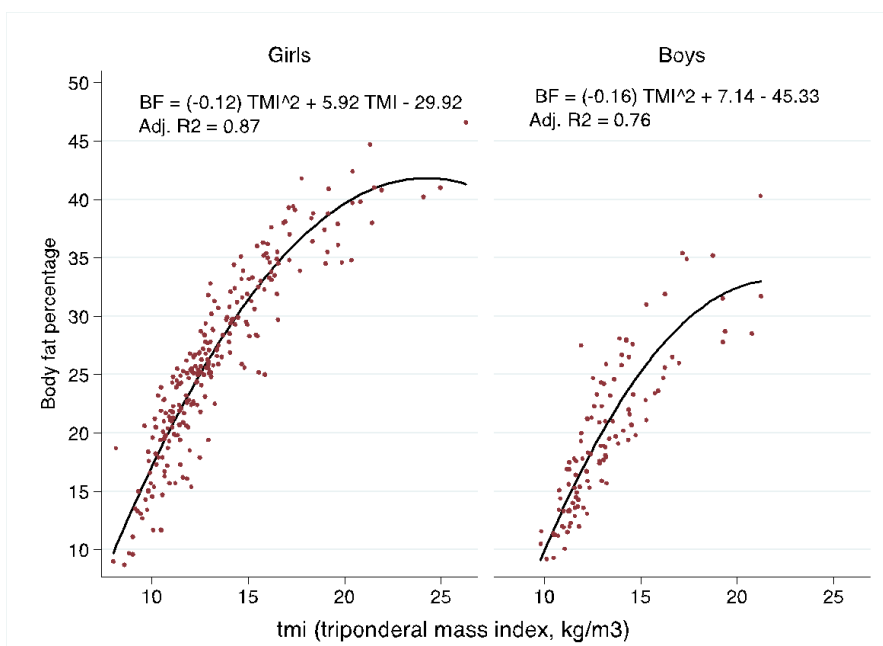


Figure 2. Body fat percentages for subjects

ages of 13 and 15. The subjects' BMI and TMI patterns are displayed in **Figure 1**. The subjects' BMI was between 14-22 kg/m², while the TMI was between 12-14 kg/m³. The patterns of body fat percentage in boys and girls increased until ages of 11 and then decreased (16.8-27.2%

and 17.8-27.6%, respectively) (**Figure 2**). **Figure 3 and 4** describe the equations for predicting percent body fat for boys and girls. The adjusted R² for TMI vs BMI was reported (R² = 0.76 vs 0.33 in boys and R² = 0.89 vs 0.87 in girls).

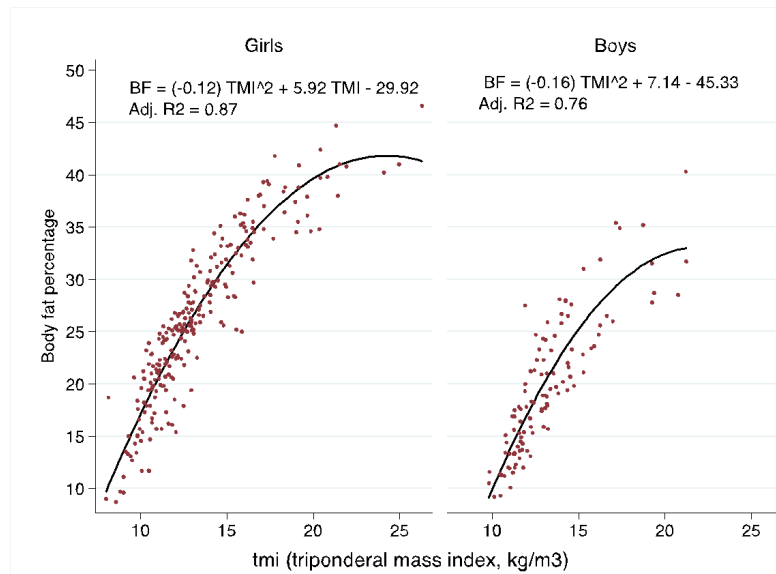


Figure 3. BMI as predictor of body fat in girls and boys

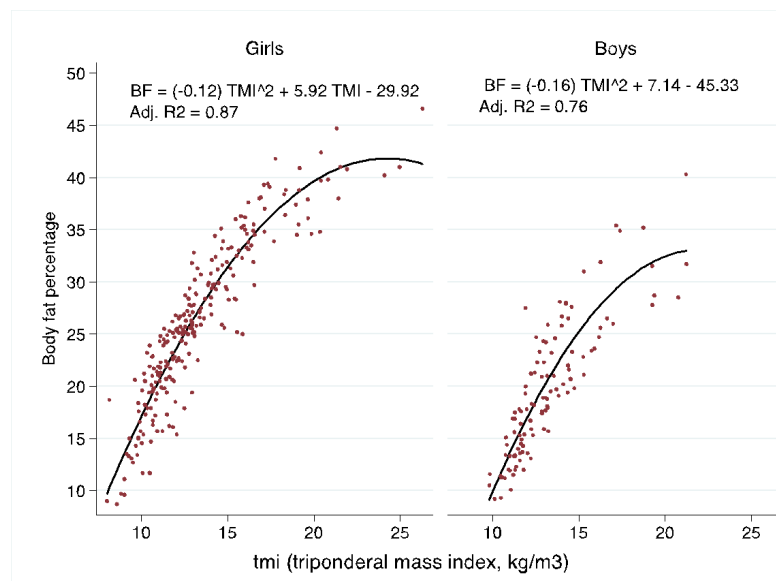


Figure 4. TMI as predictor of body fat in girls and boys

DISCUSSION

Our study revealed that TMI showed greater stability across age than BMI. The TMI means were approximately 13.0 kg/m³ between subjects less and more than 12 years, while the BMI means were 17.9 to 20.7 kg/m². The TMI predicts body fat percentage better than BMI for both sexes, especially in boys (the adjusted R² of TMI and BMI were 0.76-0.89 and 0.33-0.87).

In adolescents and children, weight and height varies with age and sex due to different pubertal stage. As a result, the normal BMI fluctuates with age. It is important that obesity in children is known to be a predictor of obesity in adulthood. Although BMI has been used as a reasonable indicator of obesity due to its convenience of calculation and its correlation with negative outcomes, BMI does not differentiate fat from

muscle, bone, and other lean body mass [7]. Because of that, it was difficult to categorize obesity based on BMI, BMI z-score method was employed. We investigate the possibility of a substitute index. Throughout age, TMI was more stable than BMI.

In this study, the result showed that TMI was a better predictor of body fat than BMI. This confirms the observations of the previous study, compared BMI and TMI to determine body fat percentage in adolescents. According to their study, TMI estimated body fat percentage more precisely than BMI in non-Hispanic white adolescents ages 8 to 17 and was more sensitive than BMI SDS for diagnosing adolescent obesity [4]. In addition, unlike BMI, TMI did not have to be calculated to obtain the SDS. Previous study evaluated TMI as a predictor of percent body fat in Italian children and adolescents. They also noticed that TMI correlated more strongly than BMI with percent body fat and had a higher range under the receiver's operating curve [4].

Prediction based on previous study, metabolic syndrome and body fat level is better predicted with TMI than BMI. This has been confirmed by previous study that conducted in Korean, Chinese, American and Colombian children [7,8,9]. Study by Park et al, of the 996 subjects classified as overweight by, 53.2% were classified as having normal TMI. Boys tended to be misclassified more often than girls (61.0% vs. 43.6%; $P < .01$, χ^2) [7]. In previous study, that found difference between ethnic groups when conducting an experiment to establish BMI specific national parks, they found that Asian and Pacific peoples had a higher body fat percentage than Europeans [8].

The limitation of our investigation was that although we had a variety of ethnic origins (Javanese, Chinese, and Arabic), the subjects may not have been representative of all Indonesian children due to the convenience sampling method. We need more subjects from different geographic regions and ethnicities to get nationwide Indonesian references for BMI and TMI.

CONCLUSIONS

The tri-ponderal mass index (TMI) is a more accurate prediction of body fat content in children ages 6 to 18 than the body mass index (BMI). Tri-ponderal mass index was a better predictor than BMI in both sexes, notably in boys.

Declaration of conflicting interests

None declared

REFERENCES

1. Department of Health and Human Services Centers for Disease Control and Prevention. Body mass index: considerations for practitioners. [series online] 2011 [cited 22 Feb 2020]. Available from: URL: <https://www.cdc.gov/obesity/downloads/bmiforpractitioners.pdf>
2. Buss J. Limitations of body mass index to assess body fat. *Workplace Health Saf.* 2014;62(6):264. doi: 10.1177/216507991406200608
3. Neovius M, Rasmussen F. Evaluation of BMI-based classification of adolescent overweight and obesity: choice of percentage body fat cutoffs exerts a large influence. *The COMPASS study. Eur J Clin Nutr.* 2008;62(10):1201-7. doi: 10.1038/sj.ejcn.1602846
4. Peterson CM, Su H, Thomas DM, Heo M, Golnabi AH, Pietrobelli A, Heymsfield SB. Tri-ponderal mass index vs body mass index in estimating body fat during adolescence. *JAMA Pediatrics.* 2017;171(7):629-36. doi: 10.1001/jamapediatrics.2017.0460
5. Khoshhali M, Heidari-Beni M, Qorbani M, Motlagh ME, Ziaodini H, Heshmat R, et al. Tri-ponderal mass index and body mass index in prediction of pediatric metabolic syndrome: the CASPIAN-V study. *Arch Endocrinol Metab.* 2020;64(2):171-8. doi: 10.20945/2359-3997000000206
6. Shim YS. The relationship between tri-ponderal mass index and metabolic syndrome and its components in youth aged 10-20 years. *Sci Rep.* 2019;9(1):14462. doi: 10.1038/s41598-019-50987-3
7. Park HK, Shim YS. Distribution of tri-ponderal mass index and its relation to body mass index in children and adolescents aged 10 to 20 years. *J Clin Endocrinol Metab.* 2020;105(3):e826-34. doi: 10.1210/clinem/dgaa030
8. Wang X, Chen Y, Ma J, Dong B, Dong Y, Liang W, et al. Tri-ponderal mass index reference values for screening metabolic syndrome in children and adolescents: results from two national-representative cross-sectional studies in China and America. *Front Endocrinol (Lausanne).* 2021;12:739277. doi: 10.3389/fendo.2021.739277
9. Ramírez-Vélez R, Correa-Bautista JE, Carrillo HA, González-Jiménez E, Schmidt-RioValle J, González-Ruiz K, et al. Tri-ponderal mass index vs. fat mass/height³ as a screening tool for metabolic syndrome prediction in Colombian children and young people. *Nutrients.* 2018;10(4):412. doi: 10.3390/nu10040412