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The diagnostic performance of mid-upper arm circumference (MUAC) for detecting thinness in adolescent girls

Kinerja diagnostik lingkar lengan atas (LILA) dalam mendeteksi kekurusan pada remaja putri

Siti Budi Utami[1*], M. Primiaji Rialihanto[2], Martha Puspita Sari[3]

[1] Department of Nutrition, Poltekkes Kemenkes Yogyakarta, Indonesia.
E-mail: sitibudiutami@poltekkesjogja.ac.id
[2] Department of Nutrition, Poltekkes Kemenkes Yogyakarta, Indonesia.
E-mail: aji.primiaji@poltekkesjogja.ac.id
[3] Department of Nutrition, Poltekkes Kemenkes Yogyakarta, Indonesia.
E-mail: martha.puspita.sari@poltekkesjogja.ac.id

***Correspondence Author:**
Department of Nutrition, Poltekkes Kemenkes Yogyakarta, Tata Bumi No. 3, Banyuraden, Gamping, Sleman, Yogyakarta 55293, Indonesia.
E-mail: sitibudiutami@poltekkesjogja.ac.id

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Abstract

Undernutrition in adolescent girls is a critical aspect of the malnutrition cycle. While early detection is necessary, the standard BMI-for-Age Z-Score (BAZ) method is difficult to implement in community screenings. This study aimed to evaluate the performance of Mid-Upper Arm Circumference (MUAC) in detecting thinness (BAZ < -2SD) in adolescent girls. This school-based cross-sectional study, conducted in 2025, involved 298 female students aged 15-17 years in Yogyakarta. Spearman's rank correlation was used to test the relationship between MUAC and BAZ, *Receiver Operating Characteristic* (ROC) analysis was used to determine diagnostic accuracy, and the Youden Index was used to determine the optimal cutoff. The results showed that MUAC had a highly positive correlation with BAZ (r = 0.907, p < 0.001) and excellent predictive accuracy (AUC= 0.972;95% CI: 0.951–0.993). The optimal MUAC cutoff was < 20.7 cm, achieving a perfect sensitivity of 100% and a specificity of 88.3%. Therefore, MUAC is an accurate and effective screening tool for predicting thinness in adolescent girls (15-17 years). The cutoff of 20.7 cm is applicable to this specific population. For national applications, further research expanding the scope to rural locations and a wider age range is highly recommended.

Keywords: Nutrition assessment, adolescent, arm circumference, thinness, screening tools

Abstrak

Kurang gizi pada remaja putri merupakan komponen kritis dalam siklus malnutrisi. Deteksi dini perlu dilakukan, namun penggunaan Indeks Massa Tubuh menurut Usia (IMT/U) sulit diterapkan dalam skrining berbasis masyarakat. Penelitian ini bertujuan menyelidiki hubungan antara Lingkar Lengan Atas (LLA) dengan Z-Skor IMT/U dan mengevaluasi akurasi LLA dalam mendeteksi status gizi kurus pada remaja putri. Studi cross-sectional berbasis sekolah ini dilakukan pada tahun 2025, dengan melibatkan 298 siswi berusia 15-17 tahun di Yogyakarta. Status kurus didefinisikan berdasarkan IMT/U <-2SD (WHO, 2007) sebagai standar emas. Kekuatan korelasi diuji menggunakan korelasi *Spearman's rank*, dan akurasi diagnostik dievaluasi melalui analisis kurva *Receiver Operating Characteristic* (ROC) dengan Youden Index digunakan untuk menentukan cut-off optimal.Hasilnya, LLA menunjukkan korelasi yang sangat kuat dan signifikan dengan Z-Skor IMT/U (r = 0,907, p < 0.001). Analisis ROC menunjukkan akurasi prediktif LLA yang sangat baik (AUC= 0.972;95% CI: 0.951–0.993). Cut-off LLA optimal adalah <20.7 cm dengan sensitivitas sempurna 100 % dan spesifisitas 88.3%. Oleh karena itu, disimpulkan bahwa LLA dapat digunakan untuk memprediksi status gizi kurus pada remaja putri (15-17 tahun). Cut-off <20.7cm dapat diterapkan pada populasi studi ini. Untuk aplikasi di lingkup nasional, penelitian lanjutan dengan cakupan lokasi (pedesaan) dan rentang usia yang lebih luas sangat direkomendasikan.

Kata Kunci: Asesmen gizi, remaja, lingkar lengan atas, kurus, alat skrining

Introduction

Adolescence represents a critical stage in the human life cycle and makes a substantial contribution to improving the Human Development Index. Based on the official population projections derived from the 2020 Population Census by Badan Pusat Statistics (BPS), the adolescent population in Indonesia is estimated to reach 44,111,800 by 2025. This demographic accounts for approximately 15.5% of the total population, with nearly half of this group being women. This developmental stage is marked by transformative growth with profound implications for the future health of individuals and the next generation (Central Bureau of Statistics of Republic Indonesia, 2025).

This developmental stage is marked by transformative growth, with profound implications for the future health of individuals and the next generation. The current cohort of adolescents is confronted with a rapidly changing nutritional environment that gives rise to multiple challenges, including food insecurity and overnutrition. Nutritional problems during this phase can impede physiological maturation, particularly in terms of muscle development, cardiorespiratory endurance, neural functioning, and immune competence. These conditions further increase the risk of non-communicable diseases (NCDs) in later life (Norris et al., 2022)

Adolescent undernutrition constitutes an integral component of the malnutrition cycle, as conceptualized in the Life-Cycle Approach theory. This framework posits that undernutrition may begin in the utero and persist across all stages of life. Undernourished adolescents are at risk of becoming undernourished adults who, in turn, may give birth to undernourished offspring ("Global Nutrition Challenges: A Life-Cycle Approach," 2000). Consequently, breaking this intergenerational cycle of undernutrition requires targeted interventions at every stage of life, including adolescence. In line with this perspective, the focus on undernutrition and stunting prevention has broadened from the First 1,000 Days of Life to encompass the First 8,000 Days of Life. This expanded framework explicitly includes adolescence particularly among adolescent girls as a critical window of opportunity for intervention (Renyoet et al., 2023).

According to the 2023 Indonesian Health Survey (SKI), the prevalence of undernutrition (thinness and severe thinness) among adolescent girls aged 13–18 years ranged from 5,1% to 5,3%, representing a slight increase from 4.3% to 5.4% in 2018. However, in the Province of D.I. Yogyakarta, the prevalence undernutrition among adolescents aged 16-18 years rose markedly from 7.6% in 2018 to 12.8% in 2023, ranking second after East Nusa Tenggara (13.1%) (Ministry of Health Republic Indonesia, 2023).

Early detection of malnutrition in adolescents is essential to ensure timely nutritional interventions and to prevent further deterioration of nutritional status (Serón-Arbeloa et al., 2022). The World Health Organization (WHO) recommends the use of Body Mass Index-for-Age (BMI/A) as the standard indicator for assessing adolescent nutritional status, with thinness defined as a BMI/A Z-score of < −2 SD and severe thinness as < −3 SD (World Health Organization, 2007). Although this method is relatively straightforward, its application requires trained personnel, properly calibrated equipment, and routine maintenance. Moreover, the use of BMI/A in community settings is challenging (Sisay et al., 2020).

Several studies have demonstrated a positive correlation between Mid-Upper Arm Circumference (MUAC) and BMI in adolescents, indicating that MUAC may serve as a simpler, more affordable, and practical alternative screening tool compared to BMI/A (Sisay et al., 2020). Research conducted in different countries has proposed varying MUAC cut-off values for adolescent girls: < 22.6 cm in Ethiopia, < 21.2 cm in Sudan, and between < 17.5–20.9 cm in India for those aged 10–19 years (Nitika, 2021). In contrast, Indonesia continues to apply a single MUAC cutoff value of < 23.5 cm across all female age groups, including adolescents and adults. Thus, a study is crucial to assess the diagnostic performance and establish an appropriate MUAC cutoff value for screening thinness among Indonesian adolescents, a crucial step currently hindered by the lack of nationally standardized reference cutoffs for this age category.

This study aimed to evaluate the diagnostic performance of MUAC in detecting undernutrition, specifically thinness defined by BMI-for-Age < - 2SD, among adolescent girls in D.I. Yogyakarta Indonesia.

Methods

This school-based observational study employed a cross-sectional design with data collected from participants at a single time point. The study population comprised all female students (girls) at Public Senior High School 2 in Yogyakarta. A total of 298 students were included in the study, as determined by sample size calculation. A total sampling method was applied to enroll all eligible students.

The minimum sample size (n) for this study was calculated using a formula for a single population proportion (Daniel & Cross, 2013), based on the following variables:

$$\mathrm{n} = \frac{Z^2 . p(1-p)}{d^2}$$

n = sample size
Z = Z-score for the desired confidence level (99% = 2.575)
P = estimated prevalence of thinness (5.3% or 0.053), based on Indonesian Health Survey (2023)
d = precision or margin of error (5% or 0.05)

Eligibility Criteria

Inclusion: female students in 10-11th grades, aged 15–17 years, healthy

Exclusion: absent during data collection, athletes, students with chronic illness, or those whose weight and height could not be measured, and unwilling to participate in this research

Data Sources

Two types of data were used in this study. The primary data included the participants' identity, body weight (BW), height (BH), and mid-upper arm circumference (MUAC). Secondary data (names, classes, and total number of students) were obtained from the school records.

Instruments

- Digital Weight scale (Onemed, Indonesia) to measure BW (±0.01 kg)
- Microtoise was used to measure BH (±0.1 cm).
- MUAC tape: to measure MUAC (±0.1 cm).
- WHO AnthroPlus v1.0.4: used to calculate BAZ for individuals aged 5–19 years.

Procedures

After obtaining ethical approval and institutional permissions, data collection was carried out, followed by data analysis, report writing, and dissemination.

Data Analysis

BW, BH, and age were converted into Body Mass Index-for-Age Z-Score (BAZ), with thinness defined as < −2 SD. Data were analyzed using IBM SPSS Statistics 31. The normality of MUAC, BAZ, and age was checked using the Shapiro–Wilk normality test. We found that the data for MUAC, BAZ, and age deviated from normality (p-value < 0.001). Hence, the median with interquartile range was employed to summarize the characteristics of the participants.

Spearman's rank correlation was used to test the correlation between MUAC, BAZ, and age. The diagnostic performance of MUAC was evaluated using ROC curve analysis involving all 298 participants. This approach assesses the sensitivity and specificity across all possible cutoff points to determine how effectively the MUAC discriminates thinness from the rest of the sample. The optimal MUAC cutoff was determined using the highest Youden Index (J = sensitivity + specificity – 1).

Ethics

All study procedures were reviewed and approved by the Ethics Committee of Poltekkes Kemenkes Yogyakarta (No. DP.04.03/e-KEPK.1/580/2025). Written informed assent was obtained from the adolescents and consent from their primary caregivers prior to data collection, following a full explanation of the study's objectives and procedures. Participants were assured of the confidentiality of their data and informed of their right to withdraw from the study at any time, without consequence.

written informed assent was obtained from the adolescents, and consent from their primary caregivers.

Result and Discussion

The study was conducted at Public Senior High School 2 Yogyakarta, where data were collected from 15 classes (eight 10th-grade and seven 11th-grade classes). The total number of girls in these classes was 315. However, 17 students were absent during the data collection process. Thus, 298 respondents participated and were included in the final analysis.

Respondent characteristics, including age, weight, height, BAZ, and MUAC, are presented as median and interquartile range (IQR): age (years) 16 (15-16), weight (kg) 48.30 (43,21–54,76), height (cm) 154,4 (150,9 – 158,2), BAZ (kg/m^2) -0,25 (-1,02 – 0,76), and MUAC (cm) 23,1 (21,4 – 25,8).

The nutritional status of adolescent girls was initially classified into three categories based on the BAZ: thinness (<-2SD), normal weight (-2SD to ≤ +1SD), and overweight (≥ +1SD). The majority of respondents were categorized as having a normal weight (75.5%). Meanwhile, 5.7% were classified as thin and 18.8% as overweight. For the final diagnostic accuracy analysis, which focused on identifying thinness, the nutritional status was simplified into two groups: thinness (BAZ(<-2SD) and non-thinness (BAZ ≥-2SD). This final classification resulted in 17 respondents (5.7%) being categorized as thin and 281 respondents (94.3%) as non-thin.

The findings regarding nutritional status in the present study indicated that the majority of adolescent girls were categorized as having normal weight (75.5%). Conversely, the prevalence of thinness was 5.7%, while a significant proportion were classified as overweight (18.8 %). When compared to the Indonesian Health Survey 2023 data for female adolescents aged 13–18 years, the prevalence of thinness in this study (5.7%) was slightly higher than the national range (5.1–5.3). Furthermore, the percentage of overweight respondents (18.8%) notably exceeded the national average (12.6–15.5%). Conversely, the proportion of normal-weight adolescents (75.5%) in this study was lower than the national figures (79.0–82.2%).

The higher prevalence of both thinness and overweight in our study population, coupled with a lower proportion of normal weight, suggests a potential double burden of malnutrition that is more pronounced in this specific context than the national average. This disparity may be attributed to local socio-economic factors, specific dietary habits, or differences in the level of physical activity within the sampled area (Mekonen & Abebe, 2025).

Relationship between MUAC, BAZ, and age

We used Spearman's rank correlation to examine the strength of the linear relationship between MUAC, BAZ, and age with 95 % CI. We found a significant highly positive correlation between MUAC and BAZ, r = 0.907 p <0001 (95 % CI 0·884, 0,926). However, MUAC did not correlated with age, r = -0.016, p=0.779 (95 % CI; –0.133; 0.101). Scatter plots showing the correlation MUAC and BAZ is illustrated in Figure 1.

The findings of this study, which indicate a positive correlation between MUAC and BAZ among adolescent girls, are consistent with those of several previous studies conducted across different regions. Studies conducted in Ethiopia reported correlations of r = 0.81 (95% CI 0.79, 0.84) and r = 0.80 (95% CI 0.775–0.822) (Sisay et al., 2020; Zebene et al., 2024). Similarly, research in India showed correlations of r = 0.63 (p < 0.001) and r = 0.78 (p = 0.001 (Nitika, 2021; Sethi et al., 2019), while a study in Sudan found a correlation of r = 0.715 (p < 0.001) (Musa et al., 2023).

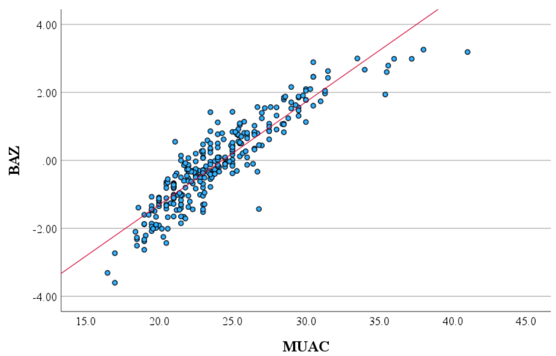

Figure 1. Scatter plots showing the correlation MUAC and BAZ

Given the consistent findings demonstrating a strong correlation between MUAC and BAZ, MUAC is effectively employed as a predictor of thinness (undernutrition) based on the BAZ criteria. The decrease in BAZ, which signifies undernutrition, was accurately mirrored by a corresponding decrease in MUAC. This is because MUAC serves as a composite measure encompassing both the arm muscle and fat areas. When an individual experiences undernutrition, the body's energy reserves (fat) and protein reserves (muscle) are depleted, which is directly and promptly reflected in the reduction of the MUAC measurement(Gibson, 2025).

Performance of MUAC to diagnose thinness (BAZ <-2SD)

The diagnostic performance of Mid-Upper Arm Circumference (MUAC) for predicting thinness (defined as, based on the WHO 2007 Growth Reference data for children and adolescents aged 5–19 years) was evaluated using a Receiver Operating Characteristic (ROC) curve analysis. The analysis yielded an Area Under the Curve (AUC) of 0.972 (95% CI: 0.951–0.993). Based on the criteria established by Swets (1988), which classifies an AUC value between 0.9 and 1.0 as 'excellent' predictive accuracy, this result clearly demonstrated that MUAC possessed excellent predictive accuracy in identifying thinness within this specific population. The ROC curve is shown in Figure 2.

This finding is consistent with previous research, which has also reported excellent AUC values for predicting thinness in older adolescents, including 0.97 (Sisay et al., 2020) and 0,91 (Sethi et al., 2019) for girl aged 15-19 years. While some studies have reported good (AUC 0.8-0.9) predictive accuracy (Nitika, 2021; Sethi et al., 2019; Zebene et al., 2024) and others fair (AUC 0.7-0.8) accuracy (Musa et al., 2023; Nitika, 2021), these variations are largely attributable to differences in the specific age ranges studied. The highest AUC values appeared to be consistently associated with older adolescents (15-19 years), which aligns with the group of the current study's sample.

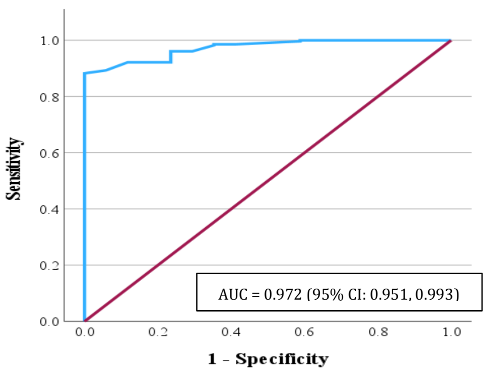

Figure 2. Receiver operating characteristics (ROC) curve showing performance of MUAC to identify thinness in adolescent girls

The ROC curve identified an optimal MUAC cut-off of < 20.7 cm to detect thinness (BAZ<-2SD; n=17) among adolescent aged 15-17 years. This threshold was selected based on the maximum Youden Index value (0.883). The diagnostic performance at this cutoff point yielded a sensitivity of 100% and a specificity of 88.3%.

The diagnostic performance of the Mid-Upper Arm Circumference (MUAC) cut-off point of <20.7 cm yielded exceptional results when validated against the reference standard BAZ, achieving a perfect sensitivity of 100% and a high specificity of 88.3%, AUC=0.972, (95 % CI: 0.951–0.993). The attainment of 100% sensitivity was a particularly robust finding, signifying that the screening tool was highly effective in identifying all truly undernourished adolescents in the study population. This absolute certainty eliminated the risk of false negatives, ensuring that no cases of nutritional risk were overlooked, thus bolstering the efficacy of public health intervention programs. The specificity of 88.3% was also highly commendable, although it implied that a small proportion (11.7 %) of normally nourished adolescents may be incorrectly identified as undernourished (false positives).

Based on the frameworks of diagnostic test utility, particularly the SNOUT (Sensitive, Negative, Out) and SPIN (Specific, Positive, In) principles as discussed by Trevethan(2017), these extreme metrics strongly validate the use of MUAC for individual screening decisions. The perfect sensitivity allows negative screening results (<20.7 cm) to confidently rule out undernutrition, ensuring that those deemed nutritionally secure require no further immediate intervention (s). Conversely, the combination of high sensitivity and specificity means that a positive test result (<20.7 cm) carries substantial weight. Therefore, adolescents who test positive should be immediately referred for definitive diagnostic evaluation and subsequent nutritional intervention, supporting the adoption of MUAC as a highly efficient and reliable field screening instrument.

Previous studies have indicated that the optimal MUAC cut-off values for identifying thinness (BAZ < -2 SD) in adolescent girls vary significantly based on age and geographical context. Age-group specific studies conducted in India yielded comparable cut-offs for younger adolescents (10–14 years): Nitika (2021) reported a cut-off of 19.4 cm (87.7% sensitivity/SN and 70.9% specificity/SP, while

Sethi et al. (2019) proposed 19.4 cm (84.0% SN and 75.4% SP). For older adolescents (15–19 years) in India, the optimal MUAC cut-off ranged from 21.6 cm (Sethi et al., 2019) to 21.7 cm (Nitika, 2021). This range provided SN between 81.4% and 87.9% and SP ranging from 77.8% to 87.1%.

Furthermore, a research by(Mramba et al., 2017), utilized data from the US Health Examination Survey (HES)/National Health and Nutrition Examination Survey (NHANES) to establish MUAC growth patterns. The researchers reported that, for female adolescents aged 19 years, MUAC-for-age z-scores of −2 and −3 (indicative of moderate and severe undernutrition) corresponded to MUAC measurements of 21.3 cm and 19.6 cm, respectively; therefore, they considered MUAC a useful screening and diagnostic tool for undernutrition in various settings.

Contextual differences were notable, as demonstrated by Sisay et al. (2020) in Ethiopia, who determined that the optimal MUAC cutoff for female adolescents aged 15–19 years was 22.6 cm. This finding exhibited a very strong diagnostic performance, with a 100.0% SN and 88.2% SP. Furthermore, Musa et al. (2023), studying a broader 10–19 years age group in Sudan, established the optimal MUAC cut-off for females was 21.2 cm (86.0% SN and 80.0% SP). Therefore, the use of MUAC cutoff values should be based on age groups within a closer age range to enhance screening performance in operational settings.

The differences in MUAC cut-off points reported across studies may be attributed to variations in adipose tissue and skeletal muscle mass among children, which could result from ethnic differences (Oyhenart et al., 2019).

Comparison diagnostic metric between new cut-off point (MUAC < 20,7 cm) with the cut-off point of MUAC <23.5cm (Indonesian Ministry of Health)

Based on the results of this study, we compared the diagnostic capability of a new cutoff point (MUAC < 20,7 cm), derived from our data, with the cutoff point of MUAC <23.5 cm, which was established by the Indonesian Ministry of Health, for detecting malnutrition in productive-age women. The results are presented in Table 1.

The diagnostic performance against the BAZ Gold Standard revealed distinct differences between the two thresholds (Table 2). The previous national standard (< 23.5 cm) demonstrated high sensitivity (100%) but critically poor specificity (51.2%). This threshold resulted in a low Positive Predictive Value (PPV) (11.0%), indicating that its use would generate a large number of false-positive results

Tabel 1. Screening test result for BAZ defined thinness with MUAC among the adolescents

Thinness according to MUAC		Thinness according to BAZ		
		Yes	No	Total
MUAC <20.7 cm*	Yes	17	33	50
	No	0	248	248
MUAC <23.5 cm**	Yes	17	137	154
	No	0	144	144

*Optimal cut-off MUAC estimated using the Youden index from our data
**Cut-off by Ministry of Health Indonesia for detecting malnutrition in productive-age women

Table 2. Comparison Diagnostic performance Metrics between MUAC Cut-off <20.7 and <23.5 cm

Cut-off MUAC (cm)	Sensi-tivity (%)	Speci-ficity (%)	PPV (%)	NPV (%)
<20.7	100	88.3	34.0	100
<23.5	100	51.2	11.0	100

PPV=Positive Predictive Value (PPV); NPV=Negative Predictive Value (NPV)

In contrast, the newly determined cutoff of <20.7 cm provided a superior overall balance in diagnostic performance. This new threshold achieved a significantly higher specificity (88.3) while successfully maintaining perfect sensitivity (100%). This substantial improvement in specificity resulted in a significantly higher PPV (34.0%). Therefore, the <20.7 cm cut-off is far more effective at correctly ruling out non-thin adolescents, making it a much more reliable tool for initial case identification.

The diagnostic comparison confirmed that the newly determined optimal MUAC threshold of < 20.7 cm provided significantly superior performance for detecting thinness (defined by BAZ < -2 SD) compared to the older national standard (<23.5 cm).

This finding critically addresses the current efficiency issues in national malnutrition surveillance. The critically low specificity (51.2%) and poor PPV (11.0%) of the <23.5 cm cutoff meant that its application generated an unacceptably high false-positive rate (nearly 49%). This poor diagnostic performance likely accounts for the significant discrepancy observed in national data, which reports a strikingly high malnutrition prevalence (e.g., 41.9 for ages 15–19 years) when using the <23.5 cm standard, yet reports a much lower thinness prevalence (5.1% to 5.3%) when measured by the gold standard BAZ (Ministry of Health Republic Indonesia, 2023).

The identified optimal cutoff dramatically addressed this deficiency. The shift to an 88.3% specificity substantially improved the reliability of the screening process, enabling the tool to correctly identify non-thin adolescents (*True Negatives*) with high certainty. Critically, this improvement in efficiency was achieved without sacrificing the ability to detect every true case of thinness, given that the optimal cutoff successfully maintained a perfect 100 sensitivity. Furthermore, the enhanced PPV of 34.0 % resulting from the <20.7 cm cut-off ensures a stronger indication of a positive test result, consequently supporting a more efficient use of limited public health resources for targeted intervention.

A meta-analysis conducted by Tang et al., (2020), encompassing data from several countries (Africa, South Asia, Southeast Asia, North America, and South America), found that optimal MUAC cut-offs for adults aged >18 years ranged from <23.5 cm to <25.0 cm to appropriately screen for underweight. The application of these adult cut-offs to adolescents aged <18 years may be inappropriate because of the physiological change characteristic of this life stage. Adolescents undergo an acceleration in the growth of fat-free mass, fat mass, and BMI (Saavedra & Prentice, 2023),which impacts the increase in MUAC as it progresses toward the stable values observed in adulthood.

Consistent with this physiological rationale, our discussion highlighted several studies that confirmed the need for lower cut-off values in adolescents aged 10-19 years, reporting a range of 19.4 cm to 22.6 cm. The optimal cutoff value determined in the present study for our adolescent sample (aged 15-17 years) was <20.7 cm. Therefore, we recommended that the use of an adult cut-off of <23.5 cm (or higher) for the detection of undernutrition in adolescent girls should be evaluated with caution or discontinued, as it would underestimate the true prevalence of thinness in this younger population

The application of a suboptimal MUAC cutoff carries significant clinical and programmatic implications. A cutoff set too high can result in overdiagnosis of thinness, leading to inefficient allocation and subsequent strain on scarce public health resources. Conversely, a cut-off established too low results in under-diagnosis, meaning vulnerable, severely undernourished adolescents at high risk of mortality are missed by screening programs and consequently fail to receive the necessary life-saving nutritional support. Therefore, establishing a nationally validated optimal MUAC cutoff is critical for maximizing the sensitivity and specificity of screening efforts. In light of these findings, the MUAC cutoff of 20.7 cm provided better performance than the MUAC cutoff of 23.5 cm. Therefore, incorporating a MUAC cutoff of <20.7 cm should be considered for detecting malnutrition in this population, especially in adolescents aged 15–17 years.

Although this study demonstrated robust diagnostic performance, it had some inherent limitations. A key limitation of our study is the small absolute number of thin adolescents (n=17) identified in our sample. Although the overall sample size (n=298) was adequate for the study design, the optimal cutoff point—particularly the observed 100% sensitivity—was estimated from a limited number of positive cases. This small event count may affect the precision and stability of the determined cut-off value; therefore, the proposed threshold of <20.7 cm requires validation in an independent, larger sample with a greater number of thin individuals before it can be recommended for widespread use.

Furthermore, the generalizability of these findings is limited by several factors. The study was derived exclusively from an urban, school-based population in Yogyakarta within a narrow age range (15–17 years) and specifically excluded athletes to avoid confounding effects of high muscle mass on MUAC measurements.

Consequently, these results may not fully represent adolescents in rural settings, different age cohorts, or those with significantly different body compositions due to high levels of physical activity. Future research encompassing a broader demographic spectrum, including rural participants and a wider age range, is essential to establish a nationally validated MUAC cutoff that can be confidently applied across the diverse Indonesian adolescent population.

Conclusion

This study concluded that Mid-Upper Arm Circumference (MUAC) is a highly accurate and valid predictor of thinness (BMI-for-Age Z-Score < -2 SD) among adolescent girls aged 15-17 years. A significant correlation between MUAC and BAZ was established, with an optimal MUAC cutoff point of <20.7 cm demonstrating high diagnostic performance. Consequently, MUAC can be used as a simple, rapid, and effective screening tool for identifying undernutrition in this population. However, to ensure national applicability, further research encompassing rural settings and a wider range of participants is required.

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