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The Accuracy of Mid-upper-arm Circumference to Estimate Body Mass Index in Indonesian Adults

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Abstract. Mid-upper-arm circumference (MUAC) is an alternative parameter to estimate body mass index (BMI) that is easy, simple, and more comfortable to measure in people who cannot stand for the measurement. This study aimed to analyze the accuracy of BMI estimated using an equation from the previous study. The subject was selected by random sampling. The subject had their age, weight, height, and MUAC recorded. Actual BMI and estimated BMI were calculated from the data. The relationship between actual BMI and MUAC was analyzed using the Spearman correlation. Wilcoxon test was used to analyze the difference between actual BMI and estimated BMI. Mean difference analysis was used to assess the tendency of under or overestimation. Sixty-five subjects volunteered with the age range 22-50 years. A solid positive ($r = 0.816$) and statistically significant ($p<0.0001$) correlation between BMI and MUAC was found in this study. There was no difference ($p=0.930$) between actual BMI and estimated BMI. The mean difference (-0.28 kg/m2) between actual BMI and estimated BMI showed the tendency of underestimate. Mulyasari's equation can be used as an alternative equation to estimate BMI in Indonesian adults when it is impossible to measure the subject in a standing position.

INTRODUCTION

In clinical practice, weight and height are measured to calculate body mass index (BMI), one of the markers for malnutrition in adults [1]. It is also used at nutrition screening to identify and prevent malnutrition in hospitals [2]. It is not always possible to measure weight or height in a standing position. People with obstacles that cannot be weighed and measured require alternative parameters.

Mid-upper-arm circumference (MUAC) has been recommended as a feasible method to identify adult malnutrition. MUAC has a positive and significant correlation with BMI. Cut-off 25.1 cm (sensitivity =92.6%, specificity=79.6%) for male and 23.9 cm (sensitivity =92.6%, specificity=76.46%) for female found to be the optimal cut-off for detecting malnutrition in adults. Every 1 cm increase in MUAC will decrease the risk of mortality by 58% [3–6].

Many studies have explored the prediction of BMI from MUAC. Powell-Tuck and Hennessy assessed the nutritional status of emergency patients in the hospital. They proposed an equation for estimating BMI for men BMI = 1.01 x MUAC -4.7 (R2= 0.76), for women BMI = 1.10 x MUAC – 6.7 (R2= 0.76) 6 (6,7). Other study formulated equation BMI = -0.042 + 0.873 MUAC (R2 = 0.609) with MUAC ≤22.5 cm for cut-off to diagnose malnutrition [6,7].

The calculation of BMI based on MUAC can emerge phenomenon of underestimating and overestimating. A Study in adult women has found a significant correlation between MUAC and BMI. However, the individual level indicates a significant difference in both underestimation and overestimation between actual BMI and BMI prediction from MUAC. Indirectly this phenomenon would affect BMI classification and nutrient requirement calculation [8]. Hence, this must be the primary consideration in selecting appropriate formula to predict the anthropometry index. The study of appropriate formulas for Indonesians is limited.

A previous study has been done on Indonesian adults aged 19-29 years by Mulyasari et al., 2019. The study formulated an equation to estimate BMI based on MUAC. The limitation of the equation was that it was not formulated using all ethnicities in Indonesia and a limited age range [9].

This study aimed to analyze the accuracy of BMI estimated using Mulyasari's equation. The equation was expected

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as an alternative for calculating BMI for Indonesian adults, especially those who cannot be measured in a standing position.

MATERIALS AND METHODS

Design, Location, and Time

This study design was a cross-sectional study. The study was conducted in Kalongan Village, East Ungaran, Semarang Regency, in November 2019. The population was Kalongan Village citizens. The study used random sampling.

Subjects

The subjects of this study were 65 people. The inclusion criteria were aged 20-50 years, not pregnant, not fasting, not having hand or foot injury, and non-disabled. The subjects have informed of the study's purpose, protocols, and possible risks, and written informed consent was obtained.

Anthropometry Measurement

Weight and height were measured in standing positions. MUAC was measured in a supine position on the left arm. Weight was measured using a digital scale (Omron, accuracy= 0.1 kg) and height to the nearest 0.1 cm using microtoise (Gea Medical). Weight and height were measured with subjects wearing clothes as light as possible and barefoot. MUAC was measured using a measuring tape to the nearest 0.1 cm. The midpoint of the upper arm is located between the tip of the acromion process and the olecranon process. MUAC was measured with an arm in the side of the subject and a palm facing upward. The arm was slightly off the surface of the examination table by placing a pillow under the subject's elbow. The measuring tape was placed around the marked midpoint. There was no fabric between the tape and the skin [2].

Data Analysis

Weight, height, and MUAC data were expressed as mean and standard deviation (SD). The correlation of MUAC and BMI was determined using Spearman correlation analysis with 95% CIs. BMI was estimated for all subjects using the formulated equation from a previous study (BMI = 1.113MUAC – 5.908) [9]. Wilcoxon test was used to analyze the difference between actual BMI and estimated BMI. Mean difference analysis was used to assess the tendency of under or overestimation.

RESULT AND DISCUSSION

The present study aimed to evaluate the accuracy of the BMI estimated equation formulated in the previous study. The equation was expected as an alternative to determining BMI based on MUAC in Indonesian adults.

In clinical practice, Nutritional Care Process (NCP) is conducted to provide high-quality nutrition care. There are four steps in NCP, and nutritional assessment is the initial step. Accurate nutritional assessment results enable dietitians to make diagnosis-specific and focused documentation that improves productivity [10]. Dietitians often encounter a problem when carrying out nutritional assessments on patients who cannot be measured or weighed. The use of reported weight and height from patients is usually incorrect, thus reducing effectiveness [11]. It requires a simple method to obtain a patient's nutritional status to overcome the problem.

MUAC is one of the simple methods that can be done in different settings. The equipment to measure MUAC is inexpensive, and the procedure is easy to perform. MUAC can be measured in standing, sitting, or supine position [2]. This study was implicated 65 subjects (male=21(32.3%), female=44(67.7%). The age range of the subjects was 22-50 years. Mean MUAC and BMI were 21.50±4.02 cm and 18.31±4.1 kg/m2 (Table 1), respectively. MUAC was positively correlated with BMI ($r=0.816$; $p<0.0001$) (Fig.1). MUAC correlates significantly with BMI in pregnancy up to a gestation of 30 weeks in pregnant adult populations. It recommended MUAC cut-off for pregnant women 30.57 cm for obesity (BMI > 30 kg/m2) and 22.8 cm for undernutrition (BMI < 18.5 kg/m2) [12].

TABLE 1. Anthropometric characteristics.

Characteristics	Mean±SD
Weight (kg)	44.00±10.9
Height (cm)	140.50±8.3
MUAC (cm)	21.50±4.02
BMI (kg/m2)	18.31±4.1

MUAC= Mid-Upper-Arm Circumference, BMI=Body Mass Index

This study found that the mean estimated BMI from MUAC was 18.02±4.5 kg/m2. No difference was found between actual and estimated BMI from MUAC (p=0.930) (Table 2). The results of the present study indicate that MUAC can be used for estimating BMI. Studies from different settings found MUAC useful to estimate BMI in adults [8,13]. MUAC reflects changes in body weight. The cut-off point MUAC for undernutrition in male adults is 240 mm [14]. Likewise, the cut-off point of <23.5 cm represent BMI <20 kg/m2 and >32 cm represent BMI >30 kg/m2[15]. The Mini Nutritional Assessment (MNA) also includes MUAC cut-off point 21-22 cm to detect malnutrition. MUAC changed by at least 10%, weight and BMI would probably also change by 10% or more [6]. Another study found that in the holy month of Ramadan, all subjects had a significant weight reduction and also showed a continuous reduction in MUAC [16].

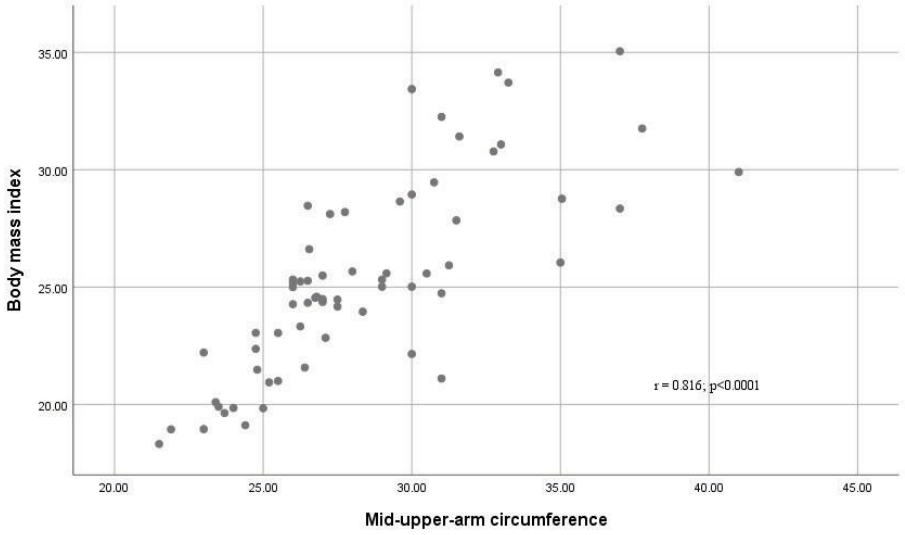

FIGURE 1. Correlation Between MUAC and BMI.

TABLE 2. The Mean Difference among Actual BMI and Estimated BMI.

	Mean±SD	SEE	Mean Difference	p-value
Actual BMI	18.31±4.1	0.51	-0.28	0.930
Estimated BMI	18.02±4.5	0.55		

BMI = Body Mass Index

In the hospital setting, MUAC has been suggested for detecting malnutrition. Malnutrition prevalence in hospitals tends to be high but often unidentified. A study in a public hospital in South Africa found that direct measurement of BMI and MUST (Malnutrition Universal Screening Tool) cannot be conducted by 38% and 43% of patients, respectively, whilst MUAC was obtainable in 100% [17]. MUAC was also significantly correlated with BMI in patients undergoing maintenance hemodialysis for stage V chronic kidney disease [18].

There is a lack of research on estimation BMI from MUAC in Indonesia. This study may be a preliminary trial in this direction. This study used healthy adults. The equation in this study was not provided sex-specific formula. It also only represents one age-group adult.

There is no consensus on the standardized equation for estimating BMI based on MUAC measurement. Further research needs to be done to obtain standardized equations that can be used generally for Indonesian adults.

Other studies have researched estimating weight and height to predict BMI [19,20]. MUAC gives a more accessible alternative to predict BMI by measuring only one parameter. This study demonstrated no difference (p=0.930)

between actual BMI and estimated BMI using the equation from the previous study. The equation had -0.28 kg/m2 mean difference of actual and estimated BMI showed the tendency of underestimate. In conclusion, this study showed that MUAC is a parameter that correlates very well with BMI and can be used as a substitute for the situations in which the subject cannot be measured in standing positions. This study results can be used as additional information on the estimation equation for BMI based on Indonesian MUAC data. It can be used as an alternative to obtaining BMI value for Indonesian adults.

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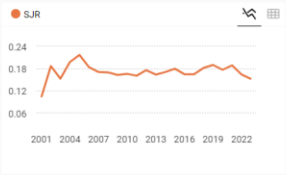
REFERENCES

1. R.S. Gibson, Principles of Nutritional Assessment. 2nd ed (Oxford University Press, New York, 2005)
2. R.D. Lee, D.C. Nieman, Nutritional assessment (McGraw-Hill, 2013)
3. A.H. Irena, D.A. Ross, P. Salama, S. Collins, Am. J. Clin. Nutr. 98 (2013) Available from: https://academic.oup.com/ajcn/article-abstract/98/2/335/4577177
4. T. Sultana, M.N. Karim, T. Ahmed, M.I. Hossain, PLoS ONE, 10 (2015) http://dx.doi.org/10.1371/journal.pone.0121456
5. C.Lorini, F. Collini, M. Castagnoli, M. Di, M.D. Bari, *et al*, Nutrition. Elsevier Inc, **30**, 171–176 (2014) http://dx.doi.org/10.1016/j.nut.2014.03.005
6. N.B. Brito, J.P.S. Llanos, M.F. Ferrer, J.G.O. García, I.D. Brito, F.P. Castro *et al*, PLOS ONE, **11**, e0160480 (2016) Available from: http://dx.plos.org/10.1371/journal.pone.0160480
7. J. Powell-Tuck, E.M. Hennessy, Clin.Nutr.**22**, 307–12 (2003) https://doi.org/10.1016/S0261-5614(03)00009-8
8. J.R. Houghton, S. Smith, *The accuracy of mid upper arm circumference as an estimate of body mass index in healthy female adults*, in Proceedings of the Nutrition Society on Malnutrition Matters, Joint BAPEN and Nutrition Society Meeting, 29-30 November 2011, Harrogate (2011) Available from: http://www.journals.cambridge.org/abstract_S0029665111003454
9. Hardinsyah, B. Koletzko, S. Muslimatun, Ann. Nutr. Metab.**75**, suppl 3 (2019) Available from: www.karger.com/anm
10. A. Ichimasa, J. Nutr. Sci.Vitaminol.**61**, S41–3 (2015) Available from: https://www.jstage.jst.go.jp/article/jnsv/61/Supplement/61_S41/_pdf/-char/en
11. J. Eriksen, S.B. Sneftrup, Eur. J. Clin. Nutr.**67**, 607–9 (2013) Available from: www.nature.com/ejcn
12. A. Fakier, M. ChB, G. Petro, S. Fawcus, SAMJ,**107**, 7 (2017) Available from: http://www.scielo.org.za/pdf/samj/v107n7/20.pdf
13. A. Indira, K. Kantha, G. Subramanyam, P. Ram ,Int. j. appl, **2**, 1025–7 (2016) Available from: https://www.allresearchjournal.com/archives/2016/vol2issue6/PartP/2-6-91-461.pdf
14. R. Chakraborty, K. Bose, S.Koziel, Rural and Remote Health, **11**, 1–12 (2011) Available from: https://www.rrh.org.au/journal/article/1754
15. M. Elia, The MUST Report. *Nutritional Screening of Adults: A Multidisciplinary Responsibility, Development and Use of the Malnutrition Universal Screening Tool (MUST) for Adults*(Redditch: Malnutrition Advisory Group (MAG), a Standing Committee of the British Association of Parenteral and Enteral Nutrition, 2003) Available from: https://www.bapen.org.uk/pdfs/must/must-report.pdf
16. M.A.K. Rohin, N. Rozano, N.A. Hadi, M.N.M. Nor, S. Abdullah, M.D. Venkateshaiah, Sci (2013) Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3842060/pdf/TSWJ2013-308041.pdf
17. E. van Tonder, L. Mace, L. Steenkamp, R. Tydeman-Edwards, K. Gerber, D. Friskin, Afr. J. Clin. Nutr. 32, 4, 93-98 (2019) Available from: https://www.tandfonline.com/doi/full/10.1080/16070658.2018.1484622
18. S.B. Bayer, F.B. Siddiqui, S.S. Ahmed, J Evolution Med Dent Sci, **6**, 73, 5183-5 (2017) Available from: https://jemds.com/data_pdf/Sujatha%20Sep%2011--.pdf
19. J. Philip, I. Zacharia, S. Paul, A. Bhatt, Int. J. Med. Sci. Public Health, **6**, 2 (2017), Available from: http://www.scopemed.org/fulltextpdf.php?mno=239034
20. D.D. Kokong, I.C. Pam, A.I. Zoakah, S.S. Danbauchi, E.S. Mador, B.M. Mandong, J. Emerg. Med. **11**, 54 (2018) Available from: https://doi.org/10.1186/s12245-018-0212-9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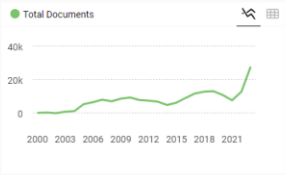
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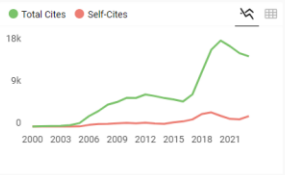
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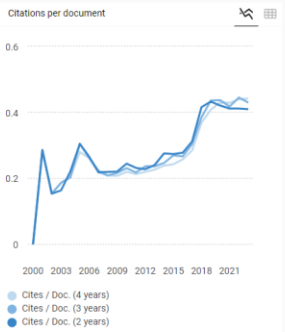
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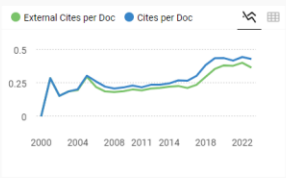
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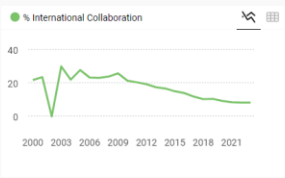
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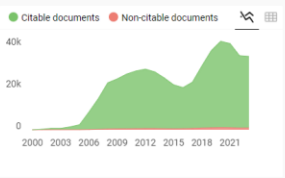
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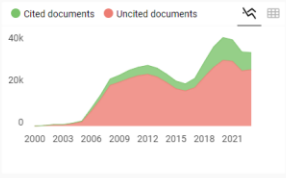
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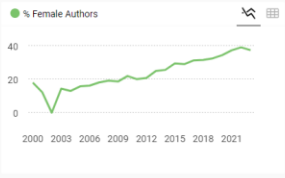
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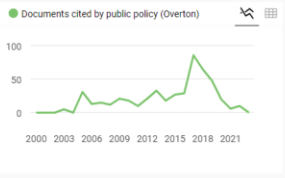
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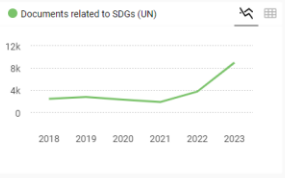
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