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Body composition in Javanese adults: some anthropometric dimensions related to body fat

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ABSTRACT

Janatin Hastuti – ***Body composition in Javanese adults: some anthropometric dimensions related to body fat***

Background: Body composition is an integral component of entirely health and physical fitness. Measurement of fat component in assessing body composition is necessary on account of its relation to several health risks. Some anthropometric measurements such as waist to hip ratio (WHR), waist and hip circumferences, skinfold thickness, and sagittal abdominal diameter are demonstrated to be valuable for evaluating body composition, and further for identifying some health risk factors.
Objectives: This study is addressed to know body composition and some anthropometric measurements related to percent body fat in Javanese adults living in Yogyakarta province.
Methods: As many as 201 (98 males and 103 females) Javanese adults living in Yogyakarta province, aged 18 to 65 years were entrolled in this study. Measurements of body weight, height, waist, abdominal, and hip circumferences, sagittal abdominal diameter, and total skinfold thickness of triceps, biceps, subscapular, suprailiac were performed on the subjects. Body composition was assessed based on those measurements included percent body fat, body density, and skeletal muscle mass. Body mass index and waist-to-hip ratio were determined and categorized. The data then were analysed using independent t-test, Pearson correlation of product moment, linear regression, and chi-square test.
Results: The result indicated that in a general sense, Javanese adults in Yogyakarta province had thin to medium body constitution and risk factor categorized of low to medium risk for males and medium to high risk for females. Javanese adult males were considerably heavier, taller, had greater means of body density, WHR, and muscle mass. By contrast, Javanese adult females were significantly higher in BMI, percentage of BF, and hip circumference. Statistically, there is no significant difference in total skinfold, abdominal circumference, and SAD, however, females indicated to a certain greater than the males. In the same manner, males had larger waist circumference.
Conclusions: All anthropometric dimensions including skinfold thickness, body density, waist circumference, abdominal circumference, WHR, sagittal abdominal diameter, and muscle mass are strongly correlated with body composition assessed with BMI and % BF. However, associations with BMI are fairly better than those of with percentage of BF. Among those measurements WHR showed the weakest correlation. There was also a different tendency in the power of correlation between anthropometric dimension with BMI and percentage of BF in males and females. Yet, all the measurements were supposed to be performed to incorporate evaluation on human body composition.

Key words: body composition - Javanese adults - anthropometric measurements - percentage of body fat.

ABSTRAK

Janatin Hastuti – ***Komposisi badan penduduk dewasa etnis Jawa: beberapa dimensi antropometrik yang paling berhubungan dengan persen lemak badan***

Latar Belakang: Komposisi badan merupakan komponen integral dari kesehatan secara total dan ketahanan fisik. Pengukuran komponen lemak dalam evaluasi komposisi badan penting dilakukan mengingat adanya hubungan antara lemak badan dengan beberapa faktor risiko kesehatan. Beberapa ukuran antropometrik

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seperti *waist-to-hip ratio* (WHR), lingkar pinggang dan lingkar pelvis, tebal lipatan kulit, dan diameter sagital abdominal diketahui dapat menunjang pengukuran komposisi badan serta lebih jauh dapat bermanfaat dalam mengetahui faktor risiko kesehatan sejak dini.

Tujuan penelitian: Penelitian ini bertujuan untuk mengkaji komposisi badan dan beberapa ukuran antropometrik yang berhubungan erat dengan persentase lemak badan pada penduduk dewasa etnis Jawa di Daerah Istimewa Yogyakarta.

Metode: Dilakukan penelitian terhadap 201 orang (98 laki-laki dan 103 perempuan) penduduk etnis Jawa di Daerah Istimewa Yogyakarta usia dewasa (18-65 tahun). Pada semua subyek penelitian dilakukan pengukuran berat badan, tinggi badan, lingkar pinggang, pelvis, dan abdomen, diameter sagital abdomen (SAD), dan tebal lipatan kulit (triceps, biceps, infrascapula, suprailiaca). Komponen komposisi badan meliputi persentase lemak badan, densitas badan, dan massa otot skeletal. Indeks massa badan (IMB) dan *waist-to-hip ratio* (WHR) dihitung dan dikategorikan. Data selanjutnya dianalisis menggunakan uji-t, uji korelasi Pearson, uji regresi linear, serta uji kai kuadrat.

Hasil: Secara umum penduduk dewasa etnis Jawa di Yogyakarta mempunyai konstitusi badan kurus dan sedang dengan faktor risiko kebanyakan dalam kategori rendah dan sedang untuk laki-laki serta kategori sedang dan tinggi untuk perempuan. Laki-laki secara signifikan lebih berat dan tinggi, serta rerata densitas badan, WHR, dan massa otot lebih besar. Sebaliknya, perempuan memiliki BMI, persentase BF, dan lingkar pelvis lebih besar. Tidak terdapat perbedaan signifikan dalam total tebal lipatan kulit, lingkar abdomen, dan SAD, meskipun perempuan menunjukkan ukuran yang lebih besar. Hal yang sama terdapat pada lingkar pinggang yang lebih besar pada laki-laki.

Simpulan: Semua ukuran antropometrik meliputi tebal lipatan kulit, densitas badan, lingkar pinggang dan abdomen, WHR, SAD, dan massa otot menunjukkan korelasi yang kuat dengan komposisi badan dilihat dari BMI dan persentase BF. Namun, korelasi terhadap BMI nampak lebih kuat daripada terhadap % BF. Diantara ukuran tersebut, WHR menujukkan korelasi yang paling lemah. Juga terdapat perbedaan kecenderungan dalam kekuatan korelasi antara ukuran antropometrik dengan BMI maupun persentase BF pada laki-laki dan perempuan. Bagaimanapun, semua ukuran antropometrik tersebut disarankan untuk dikerjakan guna mendukung pemeriksaan komposisi badan.

INTRODUCTION

Body composition is established as one of components and factors that relates to body fitness in human health.[1] Assessment of body composition involved measurement of components that constitute the human body. In general, human body are comprised of two main components i.e. fat mass and fat free mass. Measurement of fat component of the body is necessary due to its relation to several health risks in an excessive condition. As Tanaka *et al*.[2] notified in Caucasian adult males of the Quebec Family Study who were normal weight but more adiposity deposits had higher prevalence of risk factors of cardiovascular disease then males who were normal weight but less adiposity. Moreover, the prevalence in the former was nearly similar to those overweight males.

Some anthropometric measurements such as waist to hip ratio (WHR), waist circumference, skinfold thickness, and sagittal abdominal diameter suggested valuable for evaluating body composition, epidemiological and clinical survey, determining regional fat distribution, and further for identifying cardiovascular risk factor[3,4,5,6] and diabetes.[7] WHR is commonly used as an indirect measure of upper- and lower-body fat distribution. Therefore, WHR is appropriate to differentiate types of obesity based on the distribution of regional fat in upper and lower part of the body. Two terms that familiar to point that evidence are android obesity and gynoid obesity. Android obesity (apple-shaped) is more typical for male, which refers to excessiveness body fat localized in upper body or central obesity, whereas females are more characteristic of gynoid (pear-shaped) obesity that represents obesity of lower body.[8] There was a remarkable variation in WHR as well as in waist and hip circumferences among numerous populations in the world covered by the WHO MONICA Project as reported by Molarius *et al*.[9] Further, in different manners both WHR and waist circumference were available as indicators of abdominal obesity.

Waist circumference provides more accurate indirect measurements of visceral fat. Thus, it accommodates as an alternative to WHR for evaluating regional adiposity. The usage of waist circumference and BMI in combination is recommended to evaluate central adiposity and total adiposity as well as in clinical setting.[8] Previously study by Zhang *et al*.[10] indicated that measures of total and central adiposity as measured with waist circumference, as well as WHR, waist to height ratio, and waist to sitting height ratio were significantly and positively associated with the risk of cardiovascular disease in Chinese women. Waist circumference, besides measurements of BMI, WHR, and hip circumference, was suggested to be the best body measurement that applicable in predicting diabetes in Aboriginal populations as documented by Wang and Hay.[11] In addition, Moore *et al.*[12] designated that waist circumference was a strong and better predictor of colon cancer risk than BMI. It was also reported among Koreans that individuals who had high waist circumference but normal BMI had more metabolic abnormalities and metabolic syndrome than those who had normal waist circumference but high BMI.[13]

Zamboni *et al.*[14] presented that SAD by anthropometry was useful to predict visceral fat besides its very high inter- and intra observer precision. SAD as evaluated by computer tomography and SAD by anthropometry had significant association with visceral adipose tissue and subcutaneous adipose tissue. However, relationship was stronger in individuals who were lean to moderate overweight than to those who were obese. Waist circumference and WHR were also substantially related to visceral adipose tissue as SAD did.

Skinfold thickness is another anthropometric measurement that frequently applied for predicting body density from which percentage of BF is then estimated commonly implementing formulae of Brozek *et al.*[15,16] or Siri.[15,17] Many equations have generated using skinfold thickness in several parts of the body for estimating percentage of BF via three-compartment model[18], four-compartment model of body composition analyses.[17,19,20,21] Those skinfold equation for estimating relative body fat however should be carefully employed since age, sex, and ethnicity were identified to have considerable effect on the determination.

BMI also might be considered as an indicator of standard of living than a predictor of illness in developing countries. As it was found in Northeast India reported by Khongsdier[22] that low BMI and morbidity may be weigh up of ill health that affected by several biological and environmental factors such as age, economic conditions, undernutrition, save water sanitation, community pathogens, prevention and control measures of locally endemic diseases and infections. Therefore, analyses with BMI as an indicator for body fatness should be interpreted attentively. Twisk *et al.*[23] identified that there was different relationship of skinfolds and BMI concerning that BMI did not only reflect body fatness but also body leanness.

Applying BMI as an indicator of body fatness however had several restrictions since it was identified to be influenced by age and sex[20,24,25,26], ethnicity[18,26,27,28,29,30], and body shape.[31,32] Some studies indicated that at the same level of BMI, different ethnicity might result in different percentage of BF. As evidence, Wang[29] identified that Asians have greater percentage of BF at the same BMI in contrast to Caucasians. On the other hand, Polynesians living in New Zealand identified to be leaner than European at equivalent BMI levels.[33]

Investigations on the relevance of BMI and other anthropometric dimensions for evaluating body fatness in Indonesian were limited. Some researchers[18,25,27] documented that Indonesian had higher body fat at the similar level of BMI contrasting to Caucasian. Regarding to some anthropometric measures which have been described to have substantial association with body fatness and the necessity of those measurements in alarming cardiovascular risk and other metabolic disease, this study was addressed to investigate body composition of Javanese adults by evaluating some anthropometric dimensions which most related to percentage of BF.

METHODS

Investigation was carried out in August to September 2007 in four districts in Yogyakarta Province i.e. Cangkringan, Imogiri, Playen, and Kotagede Districts each of where lies in the Regency of Sleman, Bantul, Gunung Kidul, and Yogyakarta Municipality respectively. This study was provided with ethics approval by the Faculty of Medicine Gadjah Mada University. People aged 18 to 65 years old, live in Yogyakarta Province, males or females, healthy, did not have mental illness and physical disabilities were eligible for subjects of this study. Pregnant women were excluded from the subjects. Samples were randomly selected from the three communities. As many as 211 people were participated in this study including 102 males and 109 females. However, only 201 people were eligible for inclusion criteria as subjects in this study. They were consisted of 98 males and 103 females aged of 18 to 65 years. Sample size was attained from the formula of Daniel[34] for mean estimation of one population. The sample size required based on preliminary research was 199 people. The subjects were separated between males and females.

Each subject had to answer all questions on the socioeconomic data and signed the letter of informed consent before measurements were conducted. Thereafter, some anthropometric measurements were obtained including weight, height, diameter of sagittal abdominal, waist, abdominal, and hip circumferences. Skinfold thickness was observed at triceps, biceps, subscapular, and suprailiac. All the measurements were performed in accordance with standard protocol established by Lohman *et al.*[35] Body mass index was categorized in conformity with the standard of Indonesian.[36] Body density was calculated using the formula of Wormersly and Durnin.[20] Percent body fat was predicted from the body density based on the formula of Siri.[15,17] Skeletal muscle mass was determined using the formula Lee *et al.* as obtained in Lukaski.[37] The formulae were established in the followings:

Body mass index:

$$BMI = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

Category[36]:

underweight	class-2	< 17
underweight	class-1	17,0-18,5
normal		18,5-25,0
overweight	class-1	25,0-27,0
overweight	class-2	> 27,0

Waist to hip ratio:

$$WHR = \frac{waist\ circumference\ (cm)}{hip\ circumference\ (cm)}$$

Waist to hip ratio was classified into category of risk factors associated with cardiovascular disease and metabolic disease by Bray and Gray[8] norms for men and women at different age groups. Risk category was divided into low, moderate, high, and very high. Another WHR category represents hip pattern was classified into gynoid (pear shape) and android (apple shape) patterns according to Vague.[8] Each of which was value up to 0.9 and more than 0.9 respectively.

Body density[20]:

BD = C - [M ($\log_{10}$ sum of all 4 skinfolds)]

Skinfolds: triceps, biceps, subscapular, suprailiac

C and M: constants

	Age (years)				
Male	**17- 19**	**20-29**	**30-39**	**40-49**	**>50**
C	1.1620	1.1631	1.1422	1.1620	1.1715
M	0.0630	0.0632	0.0544	0.0700	0.0779
Female	**16-19**	**20-29**	**30-39**	**40-49**	**>50**
C	1.1549	1.1599	1.1423	1.1333	1.1339
M	0.0678	0.0717	0.0632	0.0632	0.0645

Percent body fat[15,17]:

$$\%BF = \left[\left(\frac{4.95}{BD}\right) - 4.5\right] \times 100$$

BD: body density

Skeletal muscle mass[37]:

Muscle mass (kg) = (0.244 x weight (kg)) + (7.80 x height (m)) – (0.098 x age) + (6.6 x sex) + race – 3,3

Sex: male=1; female= 2

Race: Asiatic= -2; Africa-America= 1; Caucasoid= 0

Data were analyzed through SPSS for Windows. Difference of means between males and females were examined by Student's t-test. Association between the anthropometric measurements with BMI and % BF was evaluated using analysis of Pearson correlation of product moment. Linear regression analysis was also explored to predict the regression line of anthropometric dimensions to BMI and percentage of BF in males and females. In addition, differences in frequencies of BMI and WHR categorizes in males and females were assessed by chi square test.

RESULTS

Means of several anthropometric measurements and body compositions of the subjects in all ages and the difference between males and females is presented in TABLE 1. In general, Javanese adult males were significantly heavier, taller, and more massive based on the body density. Males

TABLE 1. Anthropometric measurements and body composition of Javanese adult males and females in Yogyakarta Province

No.	Measurements	Males $\bar{x} \pm SD$		Females $\bar{x} \pm SD$
1.	Weight (kg)	55.24 ± 9.03	**	49.88 ± 8.97
2.	Height (cm)	161.62 ± 5.61	**	149.15 ± 4.37
3.	BMI	20.82 ± 2.36	**	22.18 ± 3.36
4.	Total skinfold[a]	32.08 ± 13.99		46.13 ± 15.53
5.	Body density	1.06 ± 0.13	**	1.03 ± 0.01
6.	% BF[b]	16.19 ± 4.48	**	28.72 ± 4.32
7.	Waist circumference (cm)	73.18 ± 7.21		71.22 ± 8.66
8.	Abdominal circumference (cm)	76.75 ± 6.95		78.63 ± 11.42
9.	Hip circumference (cm)	87.14 ± 5.90	**	89.84 ± 6.94
10.	Waist to hip ratio (WHR)	0.83 ± 0.04	**	0.79 ± 0.05
11.	Sagittal ab dominal diameter (cm)	18.47 ± 2.28		19.05 ± 2.69
12.	Muscle mass (kg)	18.66 ± 3.89	**	14.17 ± 3.43

** p<0,05; ** p<0,01; a: total skinfold of triceps, biceps, subscapular, and supraspinal; b: formula of Durnin and Wormersley[20]*

Body constitution expressed in body mass index is distributed differently between males and females as emphasized in TABLE 2. More males were underweight whose frequency was nearly equal to normal weight males, while only 10 % of the males were overweight. On the other hand, close to a quarter of females were overweight which is about in proportion to underweight category.

TABLE 2. Frequency of body mass index category and chi square test of Javanese adult males and females in Yogyakarta Province

	Males		Females		χ^2
	N	%	N	%	
Underweight	45	46	24	23	17.23**
Normal	43	44	50	49	
Overweight	10	10	25	24	
Obese			4	4	
Total	98	100	103	100	

** p<0,05; ** p<0,01*

As more females distributed in higher BMI category, the more number also indicated greater risk category of health according to the classification of WHR (TABLE 3). Approximately two third of males had low risk category and the rest one third had medium risk. By contrast, only about one eight of females had low risk, next to half had medium risk, and around one third had high risk. Further, nearly one tenth of females had very high risk while no males were identified to have it. When comparing to WHR category into gynoid and android obese patterns, the result indicated contradict as shown in TABLE 4, even there was no substantial difference.

TABLE 3. Frequency of WHR category for the risk of cardiovascular disease and the result of chi square test of Javanese adult males and females in Yogyakarta Province

Risk category	Males N	Males %	Females N	Females %	χ^2
Low	70	71	12	12	86.95**
Medium	27	28	48	47	
High	1	1	34	33	
Very high			9	9	
Total	98	100	103	100	

** p<0,05; ** p<0,01*

TABLE 4. Frequency of gynoid and android obesity based on WHR and the result of chi square test of Javanese adult males and females in Yogyakarta Province

Hip pattern	Males N	Males %	Females N	Females %	χ^2
Gynoid	85	87	97	94	3.25
Android	13	13	6	6	
Total	98	100	103	100	

** p<0,05; ** p<0,01*

Relationship between the anthropometric measurements with BMI and percentage of BF is presented in TABLE 5. Among others, body density was the only measurement which had negative relationship. Most of measurements had significant correlation with BMI and percentage of BF as well, except height with percentage of BF. However, r value of some anthropometric measurements to BMI were greater than to percentage of BF namely weight, height, total skinfolds, waist circumference, abdominal circumference, and muscle mass. By contrast, waist to hip ratio had greater r value in relation to percentage of BF particularly in males.

TABLE 5. The result of Pearson correlation of product moment between anthropometric measurements and BMI and % BF of Javanese adult males and females in Yogyakarta Province

Measurements	R BMI Males	R BMI Females	R %BF Males	R %BF Females
Weight	0.866**	0.935**	0.646**	0.667**
Height	0.306**	0.215*	0.169	0.083
BMI	1	1	0.761**	0.719**
Total skinfold[a]	0.657**	0.848**	0.857**	0.856**
Body density	-0.652**	-0.680**	-0.971**	-0.950**
% BF[b]	0.761**	0.719**	1	1
Waist circumference	0.857**	0.886**	0.777**	0.727**
Abdominal circumference	0.836**	0.662**	0.773**	0.524**
Waist to hip ratio	0.307*	0.462**	0.411**	0.477**
Sagittal abdominal diameter	0.731**	0.738**	0.743**	0.713**
Muscle mass	0.729**	0.839**	0.521**	0.503**

** p<0,05; ** p<0,01; a: total skinfold of triceps, biceps, subscapular, and supraspinal; b: formula of Durnin and Wormersley[20]*

Comparison of some anthropometric measurements and percentage of BF of Yogyakarta adults with several other populations was given in TABLE 6. Overall, it shows that Javanese adults had the lowest average of most of all anthropometric measurements and percentage of BF for both males and females compared to the other Indonesian populations as well as populations of New York (Caucasian and Negroid) .

TABLE 6. Anthropometric measurements and percentage of BF of Javanese adult in Yogyakarta Province compare to several other populations

Population	BMI	Total Skinfolds[a]	Waist Circumference (cm)	Hip Circumference (cm)	WHR	% BF
Males						
Yogyakarta	20.82 ± 2.36	32.08 ± 13.99	73.18 ± 7.21	87.14 ± 5.90	0.83 ± 0.04	16.19 ± 4.48[b]
Depok[1]	22.60 ± 3.10	53.00 ± 21.40	80.50 ± 9.00	90.50 ± 6.50		21.80 ± 6.70[b]
Makale[1]	24.00 ± 3.00	60.30 ± 24.70	83.50 ± 10.00	91.40 ± 6.20		25.90 ± 7.10[b]
New York, Black[2]	25.80 ± 3.30		89.60 ± 10.10	92.90 ± 9.50	0.96 ± 0.05	21.70 ± 7.90[c]
New York, White[2]	25.20 ± 3.10		87.50 ± 9.20	93.10 ± 8.70	0.94 ± 0.04	21.20 ± 7.80[c]
European Australian[3]	23.80 ± 2.60	42.00	80.70 ± 8.20	97.00 ± 5.90	0.83 ± 0.05	
Aboriginal Australian[3]	22.50 ± 3.20	42.20	79.70 ± 9.20	93.20 ± 6.60	0.85 ± 0.06	
Females						
Yogyakarta	22.18 ± 3.36	46.13 ± 15.53	71.22 ± 8.66	89.84 ± 6.94	0.79 ± 0.05	28.72 ± 4.32[b]
Depok[1]	21.90 ± 2.70	69.40 ± 19.70	77.00 ± 8.10	91.00 ± 5.60		31.90 ± 4.80[b]
Makale[1]	23.10 ± 3.70	69.40 ± 21.80	79.30 ± 9.90	90.50 ± 7.70		34.10 ± 5.30[b]
New York, Black[2]	27.00 ± 4.30		83.40 ± 11.80	97.40 ± 11.50	0.85 ± 0.06	35.60 ± 8.50[c]
New York, White[2]	23.30 ± 3.70		74.80± 9.50	93.00 ± 9.40	0.80 ± 0.05	30.30 ± 8.60[c]
European Australian[3]	21.90 ± 2.20	54.50	68.50 ± 5.00	94.00 ± 10.70	0.72 ± 0.04	
Aboriginal Australian[3]	22.30 ± 4.10	68.70	77.70 ± 11.30	92.70 ± 8.50	0.84 ± 0.07	

** p<0,05; ** p<0,01; a: total skinfold of triceps, biceps, subscapular, and suprailiac; b: predicted from anthropometric equation using formula Durnin and Wormerslay[20]; c: predicted from four-compartment model; 1: reported by Guricci et al.[31]; 2: reported by Gallagher et al.[26]; reported by Piers et al.[38]*

DISCUSSION

The present study indicated that eventhough females were shorter and lighter they had greater means of BMI. They were also higher in percentage of BF, abdominal circumference, and sagittal abdominal diameter. On the other hand, males show superior to females in body density, waist circumference, waist to hip ratio (WHR), and muscle mass. That females had more prominent BMI was not in agreement with some previous studies as evidence in populations of Malay Jakarta, Chinese Ujung Pandang[31], White New York[26], Caucasian Australian, and Aboriginal Australian.[38]

Sagittal abdominal diameter (SAD) was not significantly different between males and females. However, there was a strong correlation between SAD and BMI and percentage of BF as well both in males and females. This result is not exactly in accordance with previous research that reported SAD as an excellent indirect measure of visceral fat[14,39] because waist circumference was more strongly related to BMI and percentage of BF. Zamboni *et al.*[14] also documented that SAD as measured by anthropometric and by computer tomography imaging had significantly correlated with both visceral and subcutaneous adipose tissue. In addition, intra- and inter observer precision for

SAD measurements was very high. Those two previous studies indicated that SAD was strongly related to visceral adipose tissue particularly in individuals who were lean to moderately overweight than to obese people. However, at individuals who were obese or having BMI of more than 27, SAD was poorly correlated with visceral adipose tissue.[40]

Abdominal circumference as SAD was slightly greater in females but statistically not significant. Interestingly, abdominal circumference was much more adequately related to both BMI and percentage of BF in males compared to their compartment in females. Moreover, relationship with BMI and percentage of BF in males was more notable than SAD do. It is suggested that subcutaneous fat deposit at the abdomen in females, which was much greater than in males may give contribution to this result.

Investigation on WHR of Javanese in Yogyakarta shows that males had significant greater average of WHR than females. This is in accordance with WHR of males of Black and White race in New York as reported by Gallagher *et al.*[26] Moreover, Javanese males in Yogyakarta occupied more frequent of individual with android type even there was no significant difference with the frequency of their compartment of females. On the other hand, based on Bray and Gray category[8], males had remarkably less frequent of individuals with medium and high risk of disease. Most of males, a bit more than 70%, have low risk of disease is contrary to only 12% of females who have the low risk. WHR was confidently related to risk factors associated with cardiovascular disease and metabolic disease[6,8,41], and diabetes[7] as well. Despite of the usefulness of WHR some studies gave an account of several restrictions of using this index as demonstrated that WHR was influenced by menopausal status[9,42] and was not reflected the degree of overweight.[9]

Assessment on WHR category distribution is more or less consistent with BMI category that more females are overweight and obese than the males. Dealing with the use of BMI and WHR to identify individuals at risk for obesity-related disease such as cardiovascular and metabolic diseases, both have certain limitations. BMI is limited as an index of body fatness because it does not consider the composition of body weight. Further, BMI more measures subcutaneous fat than visceral fat. Relationship of BMI and percent body fat is affected by age, sex[20,24,25,26], ethnicity[18,26,27,29,] and body build.[31,32] In compare to Indonesians, Caucasians have greater BMI at the same level of percentage of BF as observed by Deurenberg *et al.*[32] On the contrary, Swinburn *et al.* noted that at higher BMI levels, Polynesians in New Zealand had significantly less fat mass but more fat-free mass than Caucasians (Europeans) particularly who had BMI over about 25. Thus, using BMI to classify obesity may obtain misclassifications of underweight, overweight, and obese and therefore, a specific standard is required to certain population including cut off point of BMI to classify obesity and or to determine risk factor of cardiovascular or metabolic diseases.

Regarding the relation between BMI and percentage of BF, this present study confirms that BMI gave strong correlation to percentage of BF (r:0.761 and r: 719 in males and females respectively). This relation was nearly as strong as that of waist circumference and percentage of BF. Therefore, it can be assumed that BMI is sufficiently relevant to assess body fatness in this population.

Waist circumference is highly related to visceral abdominal fat in men and women as reported by Han *et al.*[43] and Kamel *et al.*[41] However, males have a greater tendency to have higher mean of waist circumference (and WHR) as also provides in this study that reflects accumulation of excess fat in the abdominal region.[41] Waist circumference of Javanese in Yogyakarta shows the smallest compare to Depok, Makale[31], and New York[26] populations both in males and females. It is suggested the lower body height of the Javanese in Yogyakarta may contributes to those results along with the slighter BMI. In relation to % BF, waist circumference reveals the strongest correlation in comparison to abdominal circumference, WHR, SAD, and muscle mass[41,43] as It is also established in the relation to BMI. By contrast, WHR shows the weaken correlation. Molarius *et al.*[9] also reported considerable variation in waist circumference as well as in hip circumference and WHR among the population studied in WHO MONICA Project. Waist circumference and WHR, both used as indicators of abdominal obesity.[44]

Skinfold thickness is widely used to predict component of body composition such as body density and percentage of BF.[17,20] However, applicability of skinfold thickness for estimating body composition is limited specifically for obese persons. It was thought that the proportion of subcutaneous to total body fat changes by the increase level of fatness, hence influencing the relationship between total skinfold thickness and total body density.[8] The present study indicated that skinfold thickness also gave sufficient association to BMI, particularly in females, which was much thicker than their compartment of males (0.657 and 0.848 respectively). Moreover, total skinfold thickness had the greatest correlation to percentage of BF. This was probably because it was involved in the estimation of percentage of BF alone through the calculation of body density. Whereas, waist and abdominal circumferences, and sagittal abdominal diameter still occupying substantial contribution to percentage of BF. This finding in agreement with van der Ploeg *et al.*[19] who reported that waist circum-ference (with biepicondylar femur breadth and certain skinfold thickness) built up the best equation for the prediction of percentage of BF.

This study has limitations that the samples were taken from rural and suburban area from low to middle economic levels with heterogeneous occupations (farmer, merchandiser, civil servant, retirement, etc), and mostly low to middle education levels, hence cannot be regard as represent of overall Indonesian populations. In addition, percentage of BF was estimated by anthropometric measurements (skinfold thickness) that had several restrictions in defining body fat composition. Further investigation is recommended in larger populations and implementing gold standard methods in predicting body composition including percentage of BF such as DEXA, underwater weighing, isotope dilution, Bodpod, etc. However, this findings support some previous studies that several anthropometric measurements including skinfold thickness, waist circumference, abdominal circumference, sagittal abdominal diameter, and waist to hip ratio were reasonable for additional recommendation in evaluating body composition particularly BMI and percentage of BF.

CONCLUSIONS

All anthropometric dimensions including skinfold thickness, body density, waist circumference, abdominal circumference, WHR, sagittal abdominal diameter, and muscle mass are strongly correlated with body composition assessed with BMI and % BF. However, associations with BMI are fairly better than those of with percentage of BF. Among those measurements WHR showed the weakest correlation. There was also a different tendency in the power of correlation between anthropometric dimension with BMI and percentage of BF in males and females. Yet, all the measurements were supposed to be performed to incorporate evaluation on human body composition.

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