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ASSOCIATION BETWEEN PUBERTAL STATUS AND BODY FAT PERCENTAGE AMONG MALAY ADOLESCENTS IN KUALA NERUS, TERENGGANU

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ABSTRACT

Body composition is defined as the proportion of fat (FM) and fat-free mass (FFM) in our body. It is an important aspect of both individual's and populations' health. The rising prevalence of obesity among adolescents has highlighted the significance of body fat measurement and the factors that influence it. Therefore, this study aims to measure the body fat percentage (BF%) by using bioelectrical impedance analysis (BIA) and to observe its association with pubertal status among Malay adolescents in Kuala Nerus, Terengganu. Adolescents from 10 to 16 years old were the subject of this cross-sectional study. Weight, height, and waist circumference were measured anthropometrically, and body composition was determined using Bodystat Quadscan 4000 through BIA procedures. Questionnaires consist of socio-demographic characteristics and Tanner staging for the determination of pubertal status. A total of 310 students participated in this study (female, n=165, male n=145). The percentage of overweight and obese adolescents in Kuala Nerus was 12.9% and 10.6%, respectively. The difference in BF% between genders was significant ($p<0.001$), with pubertal girls having a greater BF% than boys (28.05±7.31% vs 17.20±8.43%). Between pubertal status and BF%, there was a significant difference ($p<0.05$). However, there was no significant association between BF% and pubertal status. Gender and pubertal status have an impact on the BF%. Thus, pubertal status should be considered when measuring BF% because it varies by individual and gender.

Key words: Adolescent, body fat percentage, obesity, pubertal status

INTRODUCTION

Human body composition study focuses on the masses of different body components and their distribution. For instance, the quantitative relations among body components, the *in-vivo* measurements of body components, and the quantitative changes in these components are associated with multiple intrinsic and extrinsic factors (Zhu & Wang, 2011). The ability to make these measurements such as using in vivo procedure (Bioelectrical impedance analysis (BIA), ultrasound imaging, air displacement plethysmography, dual-energy X-ray absorptiometry, dilution technique, magnetic resonance imaging, and magnetic resonance spectroscopy) or anthropometric measurement has progressed quickly, with advantages both to the scientist researchers and population studied (Wells & Fewtress, 2006). Body composition measurements are closely related to clinical medicine, sports science, geriatric prescription, and nutrition (Verlaan *et al*., 2017). As a result, it is essential to observe C1 the compositional nature and deviations in different health and disease states to enhance human wellbeing.

Body composition measurement is typically used to focus on the changes in body components with the risk of diseases such as AIDS, cardio-vascular risk factors, renal and various other diseases (Jahnsen *et al*., 2003). Assessment of body composition also provides information for the effectiveness of a certain treatment (Saladino, 2014) including assessing athletes' desirable body weight according to their type of sports (Jackson & Pollock, 2016)

Anthropometric assessments are the most widely used technique for evaluating body composition. Anthropometric estimations portray weight, level of

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fatness, size, and shape. However, as weight is gain or loss, the association power of anthropometric measures and indices changes. (Frisard *et al*., 2005). Thus, standardized anthropometric methods are fundamental for clinical and research study comparisons.

One of the issues, why the measurement of body fat percentage (BF%) is becoming concerned, is because of the increasing number of obese people. The prevalence of obesity in Malaysia is epidemic. For both genders, the prevalence of overweight ranges from 4.5 to 69.0 percent, and the prevalence of obesity ranges from 3.5 to 16.0 percent (Majid, 2015). Since the prevalence of obesity-related comorbidities, such as type 2 diabetes, has also increased, it is apparent that monitoring and treating obesity and its comorbidities is a major concern. Thus, it is important to assess the body composition changes in precision and the target tissue. However, our ability to assess the tissue composition of the body, specifically body fatness, limits this ability. For a variety of reasons, there is no universally recommended method for measuring or quantifying obesity, and present methods are restricted in their utility in obese people. As previously stated, existing approaches are effective for measuring both normal weight and overweight individuals, but they both have significant shortcomings. Depending on the subject population and particular characteristics required for interpretation, the clinician or researcher must choose the optimal approach for evaluating body composition according to the usefulness and limitations of available methods. (Duren *et al*., 2008).

Another issue of interest was the variations in body fat distribution that may impact all populations, such as differences between men and women, with aging, pubertal status, ethnicity, and sleep pattern (Institute of Medicine (US) Subcommittee on Military Weight Management, 2004). These differences provide different fat-free mass or fat mass predictive equations for every country because of our differences in body structure or frame. This is why the study of body composition is still being conducted now to find accurate results on why it causes a certain situation or disease to occur.

Despite many studies that have been conducted globally, the newest data on BF% among Malaysian school children, particularly in a suburban state like Terengganu, is limited (Ahmad *et al*., 2017). There is a lack of study related to body composition assessment related to the pubertal status being done in Kuala Terengganu, so limited data on obesity of individuals living in this state especially among adolescents; a transitional phase of growth between childhood and adulthood aged between 10 and 19 years (WHO, 2019). Puberty represents a period during the development of a gradual transition from childhood to adulthood. Secondary sexual development, cognitive changes, increased growth velocity, and drastic changes in body composition are all caused by endocrine changes throughout puberty. Adult body composition and risk for adult morbidities such as obesity, cardiovascular disease, and dyslipidemia may be predicted by pubertal body composition (Loomba-Albrecht & Styne, 2009).

Hence, due to this controversy, this study was conducted to determine the association between pubertal status with body fat percentage among Malay adolescents in Kuala Nerus, Terengganu. Plus, most of the studies concerning this finding were conducted on subjects age range between 20 to 60 years old. Thus, this is why adolescents (school children aged 10 to 16 years old) were chosen as the studied subjects in the present study. The result of this study can provide the mean BF% and indirectly provide the estimation of the prevalence of obesity in Terengganu. This research can also identify the association between pubertal status and BF% among adolescents.

MATERIALS AND METHODS

Study setting

This study was a cross-sectional study and was conducted in Kuala Terengganu, Terengganu. There were 137 registered schools all over Kuala Terengganu including both primary and secondary schools. Kuala Nerus district was chosen as the specific place where the study was taken over. Kuala Nerus is one of the districts in Kuala Terengganu that is governed by Kuala Terengganu City Council (MBKT). This district consists of a few major towns and villages which are Gong Badak, Seberang Takir, Batu Rakit, Batu Enam, and Kuala Nerus Town (Capital). The schools were selected randomly as listed by the Terengganu State Education Department which compromises adolescents aged between 10 to 16 years old.

Study sample

In this study, single-stage cluster sampling was used specifically. A basic random sample of clusters is chosen in single-stage cluster sampling, and data were collected from every unit in the sampled clusters (William *et al*., 2019). The participants were eligible if they were (a) Malay, (b) age between 10 to 16 years old for both genders, (c) healthy and not diagnosed with any diseases. The sample size was calculated using the single mean formula (Equation 1) with a total of 310 students required for this study (Novotny *et al*., 2006).

$$n = \left(\frac{Z_{1-\frac{a}{2}} * \sigma}{\Delta}\right) \text{ - Equation 1}$$

Ethical consideration

The consent of the participants was ensured with their verbally informed of their willingness to participate in this study. A formal meeting with all of the school principals for the selected secondary schools was held and the details of how the study is organized were informed in detail including the objectives and the procedures accompanied with the permission letters to conduct this study from UniSZA, Ministry of Education (MOE) (KPM 600-3/ 2/3-eras (4430)), and Terengganu State Education Department (JPNT) (P.T. 06030-35(22)). The ethical approval of this study was obtained from the UniSZA Health Research Ethics Committee (UHREC/ 628-2(92)). Written informed consent was obtained from parents before the data collection.

Procedures

Self-administered questionnaires on socio-demographic information were distributed by the teachers to the adolescents. For adolescents in primary school, they were asked to give this questionnaire to their parents so that they could answer it for them. This questionnaire consists of the adolescent's gender, date of birth, and health status. Apart from that, the information about the adolescent's parents was also included which comprised questions asking about their educational level, type of employment, household income, and medical history of their family.

During the data collection, the student's height, weight, hip, and waist circumference were taken with standard protocols. Their BF% was measured by using the bioelectrical impedance analysis (BIA) technique through Bodystat 4000 equipment and to measure this accurately, the adolescents were informed to at least fast for 4 hr before the measurement.

As for the measurement of pubertal status, the participants were given a questionnaire consisting of images of 5 stages of pubic hair (both sexes), genitals (male), and breast (female). They were asked to rate at which stage they are. The questionnaire also included the question, where the participants need to tick when they start their menstruation either early (below 12 years old), middle (12 to 15 years old), and late (above 15 years old) (Tanner, 1962).

Next, self-assessment of secondary sexual characteristics was used to measure maturational development, as established by Tanner (1962), with levels of maturation ranging from one to five, with one being pre-pubertal and five being posted pubertal and deemed complete maturity. Comparisons with drawings depicting the five stages of development were used to determine the self-assessment of the maturational stage. The participants were asked to assess their private parts and rate their stage (1-5) of pubertal status according to the images visualized in the questionnaire. Tanner staging was validated using the approach established by Matsudo and Matsudo (1994), which categorized adolescents in B1 and G1 as pre-pubertal, B2–B4, and G2–G4 as pubertal, and B5 and G5 as post-pubertal.

Statistical analysis

IBM SPSS Statistic 20 was used to enter and analyze all of the data. The socio-demographic features of the subjects were summarised using descriptive statistics. Based on their normality distribution, numerical data were presented as mean (SD) or median (IQR). Categorical data were reported as frequency (percentage). In addition, The Mann-Whitney U test was employed to compare the mean BF% between genders. Further, the association between pubertal status and body fat percentage among Malay adolescents in Kuala Nerus, Terengganu was determined using Fisher's Exact test (significant at $p<0.05$).

RESULTS

A total of 310 primary and secondary school adolescents from the district of Kuala Nerus, Terengganu, aged between 10 years old to 16 years old participated in this study.

Table 1 shows the mean ± SD for the age in this study was 12.9±0.1 years old in which most of them are 13 to 14 years old (n=146). There are more female adolescents (n=165) who participated in this study than male adolescents (n=145).

As for the parent's educational status and paternal smoking status, the majority of the fathers and mothers had completed secondary education (69% vs 70.6%), about 40% of the fathers are smokers, the other 60% stated non-smokers. Aside from that, most of the participants who joined in this study came from B40 (<RM 3860) group for household income, which is 48.1%. Only 14.2% were in the category of T20 (>RM 8319). The categorization of household income was based on the Department of Statistics Malaysia (2017).

Table 2 shows the anthropometric and body composition measurements of primary and secondary school children. The mean BMI of female was 21.16±0.38 kg/m^2, meanwhile for male was 18.76±0.35 kg/m^2. Both genders have the highest number of participants in the category of normal for BMI-for-age which are 34.5% and 32.6% respectively. Next, as for BF% between gender, female adolescents had 28.05±0.56% of body fat, whereas for a male adolescent was 16.95±0.69%. Females had the higher mean for weight, height, fat mass, waist circumference, hip circumference, and waist-to-hip ratio when compared to males (49.07 kg vs 43.42 kg,

Table 1. Distribution and socio-demographic characteristics of School Children

Variables	Total *n* (%)	Boys *n* (%)	Girls *n* (%)	95% CI	
				Lower Bound	Upper Bound
School (*n*=310)					
SMK Kompleks Seberang Takir	95 (30.6)	41 (13.2)	54 (17.4)	25.5	36.1
SK Kompleks Seberang Takir	96 (31.0)	55 (17.7)	41 (13.2)	25.8	36.1
SMK Kompleks Gong Badak	96 (31.0)	49 (15.8)	47 (15.2)	26.1	36.5
SMKA Dato' Haji Abbas	23 (7.4)	0 (0)	23 (7.4)	4.5	10.6
Age Group (*n*=310)					
10–11	96 (31.0)	55 (17.7)	41 (13.2)	25.8	35.8
13-14	146 (47.1)	74 (23.9)	72 (23.2)	41.6	53.6
15-16	68 (21.9)	16 (5.2)	52 (16.8)	17.4	26.8
Paternal's Education Status (*n*=310)					
No formal education	–				
Complete primary education	7 (2.3)				
Complete secondary education	214 (69.0)				
Complete matriculation	4 (1.3)				
Complete college/university	85 (27.4)				
No formal education	–				
Maternal's Education Status (*n*=310)					
No formal education	–				
Complete primary education	3 (1.0)				
Complete secondary education	219 (70.6)				
Complete matriculation	10 (3.2)				
Complete college/university	78 (25.2)				
Paternal's Smoking Status (*n*=310)					
Smoker	124 (40.0)				
Non-smoker	186 (60.0)				
Household Income[a] (*n*=310)					
<RM 3860 (B40)	149 (48.1)				
RM 3860 – RM 8319 (M40)	117 (37.7)				
>RM 8319 (T20)	44 (14.2)				

[a]Based on the Department of Statistics Malaysia (2016).

151.48 cm vs 150.54 cm, 14.66 kg vs 7.99 kg, 74.05 cm vs 69.37 cm, 88.25 cm vs 80.04 cm and 0.48 vs 0.46, respectively). However male adolescents (35.47 kg) had a higher mean for fat-free mass than female adolescents (34.55 kg). The total of BF% for overfat and obese for both genders were 25.2% and 3.9% respectively.

Table 3 shows the median difference of BF% between male and female adolescents using the Mann-Whitney U test. Females had a higher median of BF% compared to males which were 27.80 (9.55)% and 14.70 (10.70)% respectively ($p<0.001$). This result indicated that female adolescents had more BF% than male adolescents (Kirchengast, 2017).

Furthermore, Table 4 shows the median differences of BF% between pubertal stages (pre-pubertal, pubertal, and post-pubertal) using the Kruskal-Wallis test. The pubertal stage had the highest median followed by the pre-pubertal stage and post-pubertal stage, which were 24.30 (15.90)%, 14.35 (8.30)%, and 10.75 (11.13)% respectively. The result using this test showed that there was a significant ($p<0.05$) difference between tanner staging and BF% (U=9.168, P=0.010). This indicated that individuals who were in the pubertal stage had higher BF% compared with individuals who were in pre-or post-pubertal stages.

Lastly, Table 5 shows the association between pubertal stages and BF% groups using Fisher's exact test. 2.6% of individuals who were not in the pubertal stage were in the normal BF% category but none of them was overfat or obese. Meanwhile, individuals in the pubertal stage were mostly in the normal category which was 67.4%, only 30.0% were in the overfat or obese category. Nevertheless, the result showed that there was no association between pubertal stages and the BF% category.

Table 2. Anthropometric and body composition measurement among school children

Variables	Total *n*=310 *n* (%)	Female *n*=165 *n* (%)	Mean±SD	Male *n*=145 *n* (%)	Mean±SD
Body Mass Index[b] (BMI)					
Severe thinnes (<-3SD)	9 (2.9)	2 (0.6)		7 (2.3)	
Thinnes (<-2SD-≤-3SD)	21 (6.8)	5 (1.6)		16 (5.2)	
Normal (≤-2SD-≤+1SD)	208 (67.1)	107 (34.5)	21.16±0.38	101 (32.6)	18.76±0.35
Overweight (>+1SD-≤+2SD)	39 (12.9)	22 (7.1)		17 (5.5)	
Obese (>+2SD)	33 (10.6)	29 (9.4)		4 (1.3)	
Body Fat Percentage[c] (BF%)					
Normal	220 (71)	111 (35.8)		109 (35.2)	
Overfat	78 (25.2)	49 (15.8)	28.05±0.56	29 (9.4)	16.95±0.69
Obese	12 (3.9)	5 (1.6)		7 (2.3)	
Weight,kg			49.07±14.66		43.42±14.46
Height, cm			151.48±9.79		150.54±14.71
Fat mass, kg			14.66±7.64		7.99±6.08
Fat-free mass, kg			34.55±7.65		35.47±10.38
Waist Circumference, cm			74.05±11.42		69.37±11.67
Hip Circumference, cm			88.25±11.10		80.04±10.82
Waist-to-Height ratio (WHtR)[d]					
Low risk (<0.5)	213 (68.7)	105 (33.9)	0.48±0.07	108 (34.8)	0.46±0.07
High risk (≥0.5)	97 (31.3)	60 (19.4)		37 (11.9)	

[b]BMI-for-Age Z-scores, WHO (2007).
[c]Based on Heo *et al*. (2012); Taylor *et al*. (2002).
[d]Based on McCarthy & Ashwell, (2006).

Table 3. Median difference of body fat percentage (BF%) between female and male adolescents

Variables	Gender		U Statistic	*P* Value[f]
	Female (*n*=165) Median (IQR)	Male (*n*=145) Median (IQR)		
BF%	27.80 (9.55)	14.70 (10.70)	4008.50	*P*=0.000

[e] Mann-Whitney U test, significant at $p<0.001$.

Table 4. Median differences of body fat percentage (BF%) between pubertal stages

Variables	Pubertal Stage (Tanner staging, average)			U statistics	*P* value[j]
	Pre-pubertal stage (*n*=4) Median (IQR)	Pubertal stage (*n*=302) Median (IQR)	Post-pubertal stage (*n*=4) Median (IQR)		
BF%	14.35 (8.30)	24.30 (15.90)	10.75 (11.13)	9.168	0.010

[f] Kruskal-Wallis Test, significant at $p<0.05$.
[g] Tanner (1962).

Table 5. Association between pubertal stages and body fat percentage (BF%) groups

Variables	Tanner stage, *n*(%)		χ^2	*P* Value[k]
	Not in pubertal stage (stage 1 and 5)	In pubertal stage (stage 2 to 4)		
BF%				
Normal	8 (2.6)	209 (67.4)	3.519	0.111
Overfat/Obese	0	93 (30.0)		

[h] Fisher's exact test, significant at $p<0.05$.

DISCUSSION

This study was a cross-sectional study where all participants were chosen randomly from one primary school and three secondary schools around Kuala Nerus, Terengganu with an age range between 10 to 16 years old excluding year 6 (UPSR) and form 5 (SPM) students. A total of 310 students were recruited in this study comprising 165 female adolescents and 145 male adolescents.

Based on the result shown in Table 1, the prevalence of obesity among Kuala Nerus adolescents was 10.6%. It was observed that female adolescents had a higher obesity prevalence which was 9.4% compared to male adolescents which was 1.3% with the BMI-for-age indicator. The prevalence of obesity found in this study was slightly lower than that found by Ahmad *et al*. in 2017 among children (aged 10 to 17) in Terengganu which was 12%. Plus, they discovered that boys had a higher prevalence of obesity than girls in their research. This indicates that the prevalence of obesity is decreasing from the year 2017 to 2019 (Ahmad *et al*., 2017).

Several factors, including physiological changes and lifestyle variations between sexes at this age, can explain this (Wang, 2002). Girls at this age may have a much greater BMI than boys due to rapid development and physical changes related to sexual maturity and puberty. Girls often have their puberty growth spurt two years earlier than boys (Allen, 2013). Plus, in secondary schools, girls tend to participate in less physical activity, such as sports, than boys (Slater & Tiggemann, 2011).

Next, Table 3 showed that there was a significant difference in BF% between female adolescents and male adolescents ($p<0.001$). In this study, female adolescents had a higher median BF% which was 27.80 (9.55)% compared to male adolescents which were 14.70 (10.70)%. Kirchengast's (2010) findings support the results of the current study, as she discovered that girls and boys of all ages differed considerably in terms of fat mass and lean mass ($p< 0.001$). The results of the present study were also slightly similar to those of Foo *et al*. (2013) where they too found significant differences in body fatness in Malay adolescent males and females ($p<0.001$).

The reason is maybe males and females have major differences (age group 10-13 & 14-16) in tissue distribution. Males have more fat-free mass and bone mineral mass than females because they have larger arm muscles, larger and stronger bones, less limb fat, and more central distribution of fat. Meanwhile, females tend to have higher fat mass when compared to males (Karastergiou *et al*., 2012). Additionally, men store more fat in the visceral (abdominal) depot, whereas women store more fat in the gluteal-femoral area (Blaak, 2001).

On the other hand, as for the differences and association between pubertal stages and BF%, the result showed that there was a significant difference between tanner stages and BF% ($p<0.05$). Almost all of the adolescents, 302 (97.4%) were in the pubertal stage, the other 8 (2.6%) participants were in the pre-pubertal and post-pubertal stage. This is logical because most adolescents commonly are in the pubertal stage for their growth development. The composition and distribution of the body vary between sexes. During puberty, hormones cause substantial sexual dimorphism, with boys gaining more muscle mass than fat mass and girls gaining more fat mass as a natural component of their sexual and reproductive development (McCarthy & Ashwell, 2006).

However, in this study, it was found that there was no association between different pubertal status stages and the BF% group ($p=0.111$) based on Table 5. This could be due to no participants in the non-pubertal stage were found to be overweight or obese thus causing no association obtained. In a 2013 article, Cintra *et al*. emphasized that it is critical to analyze the pubertal stage because the age at which each stage is attained varies greatly. Cut-off values that just account for chronological age are insufficient for measuring obesity in adolescents since sexual maturation has a substantial impact on body composition.

There were some limitations in conducting this study. First, the tanner staging questionnaire was a self-assessment questionnaire, so, it is prone to error and bias. Students might feel embarrassed to answer the question about their private parts thus making them feel reluctant to answer the questionnaire. Other than that, there is a very limited sample of individuals who were not in a pubertal stage that are overweight or obese. Thus, the result especially, to see the differences or association is hard to analyze because of the inadequate sample. Other tests also are limited to be analyzed due to this problem.

In conclusion, this study found that the prevalence of obesity among primary and secondary adolescents in Kuala Nerus, Terengganu was 10.6% which was lower when compared with NHMS 2019 (14.8%) and Ahmad *et al*. (2017) (12%) for the children below age 18 years old. Girls had a higher BF% median than boys in this research. This could be possible because boys have more arm muscle mass, larger and stronger bones, less limb fat, and a more central fat distribution than girls. Meanwhile, girls have considerably more total adipose tissue than boys (Karastergiou *et al*., 2012). It was seen that in this study adolescent who was in pubertal stage had higher BF% than adolescents who were in pre/post-pubertal stage. The BF% of girls in the pubertal stage was discovered to be higher than that of boys in the pubertal stage. These findings suggest that pubertal status should be included when measuring BF% because it varies by individuals and gender. To prevent the increasing number of obesity among adolescents, lifestyle modification, especially through a balanced diet and physical activity, as well as positive health knowledge and behavior change, should be introduced as soon as possible. While obesity is already a major public health concern, underweight adolescents should be considered equally to avoid long-term health implications. One of the most important ways to address this issue is to provide nutritious meals to the students at school. It is also sufficient to notify the responsible parties, who must then implement and establish appropriate intervention measures to address the underlying health issues. Nonetheless, a longitudinal prospective study examining the relative risk that these adolescents face should be conducted.

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