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The exploration of adolescent girl's body composition and its relationship on hemoglobin levels in Semarang, Indonesia

Eksplorasi korelasi komposisi tubuh dengan kadar hemoglobin pada remaja putri di Kota Semarang, Indonesia

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Abstract

The prevalence of obesity and anemia in adolescents is increasing due to an unbalanced diet and lack of physical activity. Exploration of these issues is essential for balanced nutrition education, increased physical activity, and access to nutritious foods. The study aimed to explore the relationship between body composition and hemoglobin levels among adolescent girls in Semarang City, Indonesia. The study design was cross-sectional with 110 subjects aged 14-17 years from State senior high school 2, 9, and 15 Semarang. Data were collected in September-October 2022. Waist circumferences (WC), height (H), and body fat percentage (%BF) were measured using a waist ruler, microtoise, and Bioelectrical Impedance Analyzer (BIA), respectively. Waist-to-height ratio (WHtR) is defined as waist measurement divided by height measurement in centimeters. Hemoglobin (Hb) levels were determined using point-of-care testing (POCT) methods. Data were analyzed using Rank-Spearman test and Mann-Whitney test. The results showed that among all subjects, 8,2% were anemic, 21,8% were centrally obese, and 40,9% were both obese and overweight. There is no relationship between WC (p=0,54), %BF (p=0,88), and WHtR (p=0,27) with Hb levels. Also, no difference in body composition between anemic and non-anemic adolescent girls (p>0,05). In conclusion, there are no associations between body composition and Hb levels in adolescent girls.

Keywords: Anaemia, body composition, hemoglobin, adolescent girls

Abstrak

Prevalensi obesitas dan anemia pada remaja meningkat akibat pola makan tidak seimbang dan kurang aktivitas fisik. Eksplorasi masalah tersebut sangat penting sebagai bahan edukasi gizi seimbang, serta peningkatan aktivitas fisik, dan akses makanan bergizi. Penelitian bertujuan untuk mengeksplorasi hubungan antara komposisi tubuh dan kadar hemoglobin pada remaja putri di Kota Semarang, Indonesia. Desain penelitian menggunakan cross-sectional dengan subjek sebanyak 110 orang remaja putri berusia 14-17 tahun dari SMA Negeri 2,9, dan 15 Semarang. Data diambil pada September-Oktober 2022. Pengukuran lingkar pinggang (LP), tinggi badan (TB), dan persen lemak tubuh (PLT) dilakukan menggunakan waist ruler, mikrotoise, dan Bioelectrical Impedance Analyzer (BIA). Rasio lingkar pinggang-tinggi badan (RLPTB) didefinisikan sebagai perbandingan lingkar pinggang dengan tinggi badan dalam sentimeter. Kadar Hemoglobin (Hb) diambil dengan metode point-of-care testing (POCT). Analisis data melalui uji Rank-Spearman dan uji Mann-Whitney. Hasil penelitian menunjukkan bahwa diantara semua subjek, 8,2% mengalami anemia, 21,8% mengalami obesitas sentral, dan 40,9% tergolong gemuk dan obesitas. Tidak ada hubungan antara LP (p=0,54), PLT (p= 0,88), dan RLPTB (p= 0,27) dengan kadar Hb. Selain itu, tidak ada perbedaan komposisi tubuh antara remaja putri anemia dan non-anemia (p>0,05). Kesimpulan, tidak ada hubungan antara komposisi tubuh dan kadar Hb pada remaja putri.

Kata Kunci: Anemia, kadar hemoglobin, komposisi tubuh, remaja putri

Introduction

Adolescence is a critical period of growth, which is characterized by rapid physical growth and cognitive development, and is related to socioemotional factors such as social environment, economy, and culture (Sparrow et al., 2021). Adolescents' nutritional status and health conditions generally reflect their nutritional needs during childhood and describe their health conditions in adulthood. The problem of adolescent nutrition is evolving from undernutrition and overnutrition (known as double-burden malnutrition) to triple-burden malnutrition, with increasing cases of micronutrient deficiencies in adolescents (Iriyani, 2022). Adolescent girls are prone to nutritional problems due to certain conditions, such as menstruation, body image perception, and complicated psychosocial development that may be related to body image perception and reduction of willingness to eat (Mulianingsih et al., 2021; Sistiarani et al., 2023).

The proportion of overnourished adolescent girls in Indonesia was 31,9%. These proportions include overweight and obesity. The prevalence of obesity in rural areas was found to be higher than that in urban areas because of factors such as increased access to processed food, sedentary lifestyles, and economic development (Jaacks et al., 2019). Thus, global changes in diet and lifestyle are also important contributors to the increasing prevalence of obesity and overweight in rural areas (Bixby et al., 2019). On the other hand, the incidence of anemi as a manifestation of micronutrient deficiency also reaches 32%, or, in other words, 3-4 out of 10 adolescent girls experience anemia (Kementerian Kesehatan Republik Indonesia, 2019). Iron Deficiency Anemia (IDA) is the most common problem that may result in bigger health consequences in the future (Sari et al., 2022).

Body fat distribution plays an important role in iron metabolism. Adolescent girls with central obesity are at a higher risk of developing anemia due to high hepcidin levels, inflammation, and low iron levels in the body, even though they have received blood supplement tablets (Stoffel et al., 2020). Low-grade inflammation, in association with obesity, may increase the levels of inflammatory cytokines and stimulate hepatic hepcidin production, thereby disturbing cellular iron transport through ferroprotein degradation (Alshwaiyat et al., 2021; Stoffel et al., 2020).

Several anthropometric indicators can be used to determine an individual's nutritional status, including body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). BMI is a common anthropometric index used to assess the nutritional status. However, BMI has limitations as a predictive tool for degenerative diseases, such as diabetes and cardiovascular diseases, because it does not distinguish muscle mass, adipose tissue, or fat mass. BMI is also unable to consider micronutrient deficiencies (Khanna et al., 2022; Wu et al., 2024). Waist circumference and WHtR are anthropometric indicators that can be used to determine abdominal and visceral obesity. Waist circumference is known to be a more effective indicator of health than BMI and WHR, while WHtR is able to be a predictor of health problems such as hypertension, type 2 diabetes mellitus and cardiovascular disease (Mangla et al., 2020; Ross et al., 2020; Sweatt et al., 2024).

Semarang is an urban city experiencing disruptions in diet and lifestyle, as the study showed a low moderation score indicated that subjects tend to consume high fat high sodium, dan low quality diet (Dieny et al., 2020) Thus, it is interesting to explore the body composition profile of adolescent girls and its relationship to hemoglobin levels in Semarang City, Indonesia.

Methods

This is a cross-sectional study conducted on SMA Negeri 2 Semarang, SMA Negeri 15 Semarang, and SMA Negeri 9 Semarang. Data were collected from September 2022 to November 2022. The sample size was determined using the formula used in a cross-sectional study. The Z_{α} and Z_{β} value are 1,96. The correlation coefficient from a previous study was 0,4. Based on the calculation of the sample size, 100 samples were needed plus 10% out dropout, so the total sample was 110. The subjects were recruited using a purposive sampling technique. Sample inclusion criteria include (a) being 14-17 years old or sitting in classes X and XI. The exclusion criteria are (a) Currently having period, (b) not present when collecting the study data, (c) the subject refuses to continue the research.

Data collected in this study included percent body fat (%BF), waist circumference (WC), height, and hemoglobin levels (Hb Levels). Hemoglobin level data were obtained using the point-of-care testing (POCT) method with the HemoCue device. According to World Health Organization (WHO), Samples are defined to be anemic if the Hb level is < 12 g/dl and not anemic if the Hb level is ≥ 12 g/dl. Nutritional status was defined using several indicators: percent body fat, WHtR, and waist circumference. The height was measured using a microtoise instrument with an accuracy of 0,1 cm. Waist circumference was measured using a waist ruler with an accuracy of 0,1 cm. Body fat percentage was analyzed using a bioelectrical impedance analyzer (BIA). The waist circumference-height ratio (WHtR) is obtained by dividing the waist circumference (cm) by the body height (cm).

Data were analyzed for normality using the Kolmogorov-Smirnov test and bivariate analysis using the Spearman rank correlation test. This research was ethically approved under number 002/KEPK-FKM/UNIMUS/2023.

Result and Discussion

The subjects in this study were female students from classes X and XI, with an age range of 14-17 years. Most subjects had a normal nutritional status based on the WC and WHtR anthropometric indicators (Table 1). Based on the body fat percentage indicator, the overfat and obesity rates were found to be quite high (23,6% and 17,3 %, respectively). The majority of the subjects in this study did not experience anemia (Hb≥ 12 g/dl). However, 8,2% of the participants experienced anemia.

Table 1. Subject's Characteristics

Variable	n	%
Age		
14-15 y.o.	36	32,7
16-17 y.o.	74	67,3
Waist Circumference		
Normal	86	78,2
Obesity	24	21,8
Percent Body Fat		
Under-fat	6	5,5
Normal	59	53,6
Overfat	26	23,6
Obesity	19	17,3
Hemoglobin Level		
Normal	101	91,8
Anemia	9	8,2

Table 2. Relationship between waist circumference, percent body fat, and WHtR with hemoglobin levels

Variable	p-value	r
Waist circumference	0,54	0,058
Percent body fat	0,88	-0,015
WHtR	0,27	0,106

The results of the correlation analysis using the Spearman rank test showed that there was no relationship between hemoglobin levels and waist circumference, percent body fat, and WHtR (p > 0,05) (Table 2). This study is contrary to (Kerkadi et al., 2021) A study indicated that Subjects with a higher waist circumference had lower serum Hb, serum iron, and transferrin saturation compared to those with normal waist circumference. This study also found that women with a higher waist circumference showed a significant increase in CRP levels, which indicated inflammation in subjects with central obesity.

According to this theory, women tend to have a higher body fat percentage than men. Adipose tissue in women is found more in the thighs and calves; therefore, women have a higher risk of obesity, especially gynoid obesity (Karastergiou et al., 2012). The categorization of nutritional status can be performed using anthropometric measurements. Measurements of the human body are influenced by genetic, environmental, social, cultural, lifestyle, functional, and health-related factors. Anthropometric measurements can be used to evaluate the likelihood of malnutrition, obesity, muscle loss, excessive fat, and uneven distribution of fat. Circumferences, skinfold thickness, and body weight are potential factors that can be altered, whereas height and bone diameter cannot be altered (Padilla et al., 2021). Waist circumference and waist circumference-height ratio measurements are known to be more sensitive measurements for determining obesity status in adolescents than body mass index according to age, with sensitivity and specificity >0,8 (Mulyasari & Pontang, 2018).

Adolescent girls, in general, have a higher risk of anemia than adolescent boys. This is caused by various factors, such as menstruation, which causes loss of blood and iron contained in it in large volumes (Puspitasari et al., 2022). Dietary patterns also play an important role in the development of anemia in adolescent girls. A study found that unhealthy dietary patterns

increased the possibility of anemia by four times compared to healthy eating practices (Vaira et al., 2022). A Study found that low consumption of animal foods, fruits, peanuts, and vegetables are some factors related to iron-deficiency anemia. Lack of awareness of consuming iron-rich food, supported by increasing habits of iron-inhibiting food consumption, such as coffee and tea after eating, may worsen the condition, increasing the risk of having iron deficiency anemia (IDA) (Belali, 2022; Riskika et al., 2023). Adolescent girls with low iron intake are eleven times higher of protein-energy-malnutrition (Telisa & Eliza, 2020). Adolescent girls also display a unique characteristic of striving for ideal body weight. They tend to limit their intake, and, for the long term, it affects their dietary habit (Gandhi, 2022).

Obesity is also known to be a factor that can cause anemia in adolescent girls. A high percentage of body fat, which is positively correlated with obesity incidence, can cause low-grade inflammation. This mechanism causes an increase in serum hepcidin and interleukin-6 levels. As a response to inflammation and infection, an important component of the immune system, called toll-like receptors (TLR), causes the erythropoiesis process to become ineffective, thus causing anemia (Alshwaiyat et al., 2021).

The absence of a relationship between nutritional status based on waist circumference, waist circumference-height ratio, and body fat percentage in this study could be due to the fact that the majority of subjects in this study, according to hemoglobin levels, were not considered anemic. Another reason that may support this result is that anemia is a late-stage iron deficiency. There are several phases prior to iron deficiency anemia. Low ferritin levels characterize the first phase of iron depletion. The second phase, iron deficiency without anemia, are observed as low in ferritin, serum iron, transferrin, but still normal in hemoglobin levels. Furthermore, Iron deficiency with anemia represents extreme iron depletion and shows noticeable signs and symptoms. As this event occurs, there is a decrease in erythropoiesis in the bone marrow which leads to low hemoglobin concentrations and the development of IDA (Yang et al., 2023).

This research will be of interest for further development. This is because the prevalence of obesity and anemia in adolescent girls has shown an increasing trend. Several factors can be added as determinants of the risk of obesity and anemia in adolescent girls.

Conclusion

There was no correlation between hemoglobin levels and waist circumference, waist circumference-height ratio, and percent body fat in adolescent girls in Semarang City. Further research should be conducted on larger subjects to determine the factors that influence hemoglobin levels in adolescent girls.

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