Correlation between body mass index and haemoglobin level of adolescent girls in Tangerang's stunting locus area, Indonesia

Journal:	*Malaysian Journal of Nutrition*
Manuscript ID	mjn.2023.0064.R2
Manuscript Type:	Original Article
Keywords:	anaemia, body fat, body mass index, girl

Correlation between body mass index and haemoglobin level of adolescent girls in Tangerang's stunting locus area, Indonesia

Commented [NN1]: The Title was revised according to suggestion from reviewer 1, which is to be suited with the objective.

In the objective: correlation BMI >< Hb

Commented [NN2]: Anaemia problem was added here as suggested by reviewer 1

Commented [NN3]: The sampling method and inclusion criteria were added as recommended by reviewer 1

ABSTRACT

Introduction: In Indonesia, anaemia is known to be extremely common in the female adolescents. In addition, the problem of overweight/obesity in teenagers is becoming more prevalent, even in stunting locus areas. This study aims to examine the correlation between body mass index (BMI) and haemoglobin levels among adolescent girls in Tangerang's stunting locus area. **Methods:** This cross-sectional study included 171 adolescent girls attending four junior and senior high schools in Tangerang's stunting locus area. Adolescents who matched the inclusion criteria—being healthy, having lived in Sukamantri for more than six months, and willing to participate—were chosen by a multistage cluster sampling procedure. Body weight and fat were weighed by Bio-electrical Impedance Analyzer Tanita BC-541 (Tanita Corp., Tokyo, Japan). *Z-score* for BMI-for-age was determined to analyze nutritional status. Haemoglobin levels were measured by the Mission Hb Testing System. Multiple linear regression test was applied for the analysis. **Results:** The prevalence of thinness/severe thinness, normal, and overweight/obesity was 5.3%, 70.8%, and 23.9%, respectively. There were 20% of anaemic girls. Among anaemic girls, there were overweight/obese (26%) and no thin/very thin girls (0%). A weak negative correlation between BMI with haemoglobin levels were observed (R-$square$ = 0.054, p<0.01). **Conclusion:** The correlation of body mass index to hemoglobin level is weak in our sample of adolescent girls in stunting locus area. The current study emphasizes the importance of additional research that includes several haematological and inflammatory biomarkers to better understand the complex relationship between nutritional status and haemoglobin level, which is still controversial.

Keywords: anaemia, body fat, body mass index, girl.

INTRODUCTION

Anaemia is a serious global public health issue that particularly affects female adolescents. Anaemia is known to be extremely common in low-income countries and more common in the female population. Anaemia is defined as haemoglobin (Hb) levels <12.0 g/dL in women. Untreated anaemia in adolescence increases the anaemia risk in pregnancy. The latest national data showed that there is a dramatic increase in anaemia prevalence among pregnant women reaching 48.9%. The prevalence of anaemia in female adolescents is increasing at an alarming rate (Indonesian Ministry of Health, 2018). Anaemia in adolescence results in decreased mental and physical capacity and educational performance (Sari et al., 2022; Zeleke et al., 2020). It also causes a serious threat to future safe pregnancy in adolescent girls (Handari et al., 2022).

Commented [NN4]: The structure of the introduction was started by anaemia, and it was suited with the introduction in abstract (the introduction is abstract was repaired, thank you reviewer)

Anaemia is caused by a poor intake of nutrients, particularly iron. Although it is known that a deficiency of iron causes 50.0% of all anaemia cases, it still needs to assess the cause of anaemia based on specific and local factors. The deficiency of protein, vitamin A, B12, copper, and folate can also cause anaemia, as well as malaria, HIV, tuberculosis, and parasitic infections (Mrimi et al., 2022). Anaemia results in a variety of symptoms, including fatigue, weakness, sleepiness, shortness of breath, and dizziness. In addition, anaemia has been linked to lower levels of academic achievement and productivity.

On the other hand, overweight/obesity is one of the most frequently stated problems in adolescents, it is a growing public health concern. After Singapore, Indonesia has the second-highest percentage of obese teenagers (12.2%), followed by Thailand (8%), Malaysia (6%), and Vietnam (4.6%) (Liberali et al., 2020). Based on a national survey, the prevalence of obesity among teenagers was increasing two until three times from 1993 to 2014 (Oddo et al., 2019).

Commented [NN5]: The overweight/obesity prevalence was added in these two paragraphs, as proposed by reviewer 2

Indonesia has a 20% prevalence of overweight and obese teenagers between the ages of 13 and 15 and a 13.6% prevalence among obese adolescents between the ages of 16 and 18. Compared to 2013, there has been a rise in the prevalence of obese teenagers in Indonesia. The prevalence of obesity among adolescents aged 13 to 15 years has climbed by 0.4%, while the prevalence of obesity among adolescents aged 16 to 18 years has increased by 2.2% (Ministry of Health Republic of Indonesia, 2019). The prevalence of overweight/obesity is increasing in adolescent girls than in boys (Rachmi et al., 2017).

Anaemia is often multifactorial and not an independent phenomenon. Recently, considerable literature has grown up around the theme of the co-occurrence of overweight/obesity and anaemia. A cross sectional study using most recent Health Surveys of 52 countries showed an increased tendency of anaemia and obesity concomitantly in adolescent girls (Irache et al., 2022). Studies undertaken in Indonesia provide conflicting evidence concerning the relationship between BMI and anaemia or haemoglobin level. Some cross-sectional studies observed that adolescent girls with overweight are more at risk for anaemia (Sandy et al., 2021;

Syah, 2022). However, other cross-sectional studies showed that there are no relationships between overweight/obesity with anaemia (Adiyani et al., 2020; Mulyani et al., 2021). Some observed that underweight female adolescents are riskier of anaemia (Risna'im et al., 2022; Enggardany et al., 2021).

Commented [NN6]: BMI word was deleted, as suggested by reviewer 1

In Indonesia, the problem of overweight/obesity in teenagers is becoming more prevalent, as is the problem of anaemia, even in stunting locus areas. Numerous initiatives have been put in place by the Indonesian government with the goal of eliminating stunting and reaching the target of 14% by 2024. Combating anemia in teenage females is where the program's strategy started, particularly in some of Indonesia's stunting locus areas. Nevertheless, overweight and obesity, which have recently increased significantly among girls even in the stunting locus area, have not been taken into consideration by the programs aimed at eliminating anemia. The program's efficacy may be hampered if the growing issue of obesity among teenagers in stunting locus areas—who are susceptible to anemia—is not taken into account.

Commented [NN7]: Line 81 to 89 was added to elaborate why stunting locus area, as suggested by reviewer 2. Thank you reviewer 2.

There are limited studies on the relationship between BMI and haemoglobin levels in the stunting locus area in Indonesia. This study, therefore, set out to examine the correlation between body mass index (BMI) and haemoglobin levels among adolescent girls in Tangerang's stunting locus area, Indonesia.

MATERIALS AND METHODS

Study Design and Sampling

This cross-sectional study was conducted in Sukamantri village, a village with significant stunting issues in Tangerang Regency. Sukamantri has a large population. The high population density was triggered because of the establishment of many manufacturing industries. This research was carried out from May to December 2022. This research has received ethical approval from the Esa Unggul Research Ethics Commission Number 0922-10.027 /DPKE-KEP/FINAL-EA/UEU/X/2022.

In this stunting locus, there are eight junior and high schools and 756 teenage girls enrolled in total. The study involved adolescent girls attending four schools in Sukamantri village, which included two junior high schools (SMPN 2 Pasarkemis and SMP Tunas Harapan) and two senior high schools (SMK Persada and SMK Tunas Harapan). These four schools were chosen over the other four in this stunting locus area due to their higher proportion of female students.

Commented [NN8]: 'How four schools was selected ' was added here as suggested by reviewer 2

The sample size was counted using the formula Lemeshow. This study was a subset of the parent research, which had used the sample size formula to assess the output of the anaemia reduction program (percentage of anaemia in adolescent girls) in this stunting locus. According to the prevalence of anaemia of 23.9% among adolescent girls, a total of 171

Commented [NN9]: This statement was added to explain why use formula Lemeshow.

samples were taken at a 95% confidence interval and 6.0% absolute deviation of the sample from the population rate. The samples were selected using a multistage cluster sampling method. The first, cluster sampling was carried out proportionally to the number of female students in each school. The second, a systematic random sampling technique was applied to select samples in each class. The interval in systematic random sampling had been determined by dividing the total number of teenage girls enrolled in the school by the required sample size. Based on the sequence of female students' names in the attendance book from classes 1 through 3, the resulting interval number was utilized to choose teenage girls.

Commented [NN10]: How to define the interval was explained here, as asked by reviewer 2

Criteria for selecting the subjects were as follows: 1). has lived in Sukamantri for more than six months; 2) healthy; 3). not having period at the time of blood collection; and 4) willing to be a respondent. Exclusion criteria were: 1). being sick; and 2). absent during the data collection process. Prior to data collection, the respondents received an explanation of the purpose and benefits of the study. Respondents who were willing and agreed to be respondents signed an informed consent sheet.

Commented [NN11]: Exclusion criteria were added as asked by reviewer 2

Data Collection

Sociodemographic characteristics of female adolescents, including age, parent's education, family size, the experience of receiving counselling on anaemia, menstrual status, and menarche age, were collected using a structured interviewing questionnaire. Body weight and fat were weighed by Bio-electrical Impedance Analyzer (BIA) Tanita BC-541 (Tanita Corp., Tokyo, Japan). Weight measurement was conducted at least two hours after eating or exercise. After tuning on the unit, setting the respondent's age, gender, and height proceeded. Before stepping on the measuring platform, respondents removed their socks, shoes, and heavy clothing, and were requested to ensure that their feet were clean. Then, the respondent was asked to step onto the scale once "0.0" appears on the display. Weight will be displayed first, then continue standing on the scale until the body fat percentage reading appeared on the display.

Height measurements were obtained using a microtoise mounted to a wall around 2 meters away. Before taking the measurement, respondents were requested to remove their shoes and stand with their backs to the wall and face ahead. The backs of their feet, calves, bottom, upper back, and head should make contact with the wall. They should be directly beneath the drop-down measurement instrument. The anthropometry measurements were carried out by trained enumerators.

Commented [NN12]: This statement was added here as asked by reviewer 2 about who did measurement of body weight and height

Haemoglobin levels were identified by taking capillary blood at the fingertips using the Mission Hb Testing System (Hb Within Run Precision ≤3%; Hb Total Precision CV ≤3%; accuracy: venous blood R^2:0.992, capillary blood R^2: 0.993) (ACON Laboratories Inc, 2023). Some studies observed that Hb concentration determined by Mission Hb Testing System is comparable and acceptable agreement with that determined by the haematology analyser (Dua et al., 2021; Olatunya et al., 2016; Sahoo et al., 2021). It works using the reflectance photometry method. The blood sampling techniques were: 1). Remove the first drop of blood; 2). Apply light pressure to get a second drop of blood; 3). Collect 10 µL of capillary blood using a capillary transfer tube or pipette; 4). Hold the tube slightly down and touch the tip of the tube to the drop of blood. Automatically the blood sample will be drawn up to the filling line; 5). Align the tip of the tube with the strip area so that a drop of blood (about 10 µL) can be applied to the strip area. The haemoglobin measurement was performed by a laboratory analyst.

Data analyses

In descriptive analyses, the continuous data were shown as mean and standard deviation. The frequency distribution was described based on age, menstruation, nutrition status, percent body fat, family size, parents' education, and experience of getting counselling on anaemia. Based on the Nelson Textbook, adolescence is a period from 10 years to 21 years of age. It is divided into three stages, namely early (10-13 years), middle (14-17 years), and late (18-21 years) adolescence (Kliegman et al., 2020). Age was constructed based on these three age stages for descriptive analyses.

Body Mass Index (BMI) data was determined by BMI- for-Age (BMI/A). *Z-score* for BMI-for-age was determined and classified using WHO AnthroPlus software. It was classified into thinness/severe thinness (<-2.01 *SD*), normal body weight (-2.00 *SD* to +1.00 *SD*), and overweight/obesity (>+1.01 *SD*). Classification of percent body fat is based on age-specific cut-off from the body fat reference curves (McCarthy et al., 2006) and divided into two groups (normal and overfat). The haemoglobin levels were categorised as normal (≥12.0 g/dL) and anaemia (<12.0 g/dL) for descriptive analysis.

The statistical analysis was performed using IBM SPSS Statistics for Windows, version 29. (IBM Corp., Armonk, N.Y., USA). The normality test used the Kolmogorov–Smirnov. Independent t-test and one-way ANOVA were used to compare mean haemoglobin levels by each group. The correlation between body mass index and haemoglobin level was analysed using multiple linear regression. The level of statistical significance is at 5.0%.

Researchers have recognized that bivariate analysis alone might not be adequate particularly for complex data sets. Multivariate analysis can produce additional, and sometimes contradictory, results. During data analysis, it is common practice to incorporate in multivariate analysis only variables that are statistically significant in bivariate analysis. Such a practice is risky because some variables that were not significant in bivariate analysis might turn significant in multivariate analysis. The presence of a confounding factor is one of the possible scenarios in which the above situation could occur (Lo et al., 1995). In this bivariate analysis, there was no significant correlation between BMI and hemoglobin level, however when body fat was included in the model, the change of beta coefficients in BMI became extensive (>20%) and the correlation became significant. The beta coefficient change of more than 20% (Lee & Burstyn, 2016) revealed that body fat was a confounding factor.

Commented [NN13]: Line 205-215 (of discussion in previous manuscript) has been moved to method as recommended by reviewer 1.

RESULTS

The middle age range (14–17 years) accounted for the majority (50.9%) of adolescent girls. Almost all (97.1%) respondents had reached menarche age. Typically the parents have graduated from senior high school. The majority of teenage girls (60.2%) were from small households (≤4 people). Most of the adolescent girls (72.5%) admitted they had never received counselling on anaemia.

There were still thin and very thin (5.3%) adolescent girls around. The majority of the female teenagers in this study (70.8%) have a normal BMI. Overweight and obesity were becoming more common in adolescent girls. Adolescent girls were overweight/obese at a rate of 23.9% (14.4% overweight and 9.5% obese). It included a high level (>10.0%) of overweight problems, based on a cut-off of nutrition problems of public health significance. The proportion of overweight/obese adolescent girls was nearly five times that of thin/very thin adolescent girls and higher than the national average (23.9% vs. 13.0%).

Almost one-third (23.4%) of respondents have overfat, whereas 76.6% have normal body fat. The average age of menarche is 11.6+0.9 years. Almost all (97.1%) of them had menstruated. The average haemoglobin concentration was 13.1±1.5 g/dL. Anaemia affected 19.9% ≈ 20.0% of adolescent girls. It included a middle level (20.0-39.0%) of health problems based on a cut-off of nutrition problems of public health significance (World Health Organization, 2015).

There was no anaemia found in thin or very thin female adolescents. Anaemia was more prevalent in overweight/obese and normal-weight girls compared to thin/very thin girls (Table 1). There were no differences in mean haemoglobin levels based on menstrual status, nutrition status (BMI/A), level of percent body fat, parents' education, household size, and having received anaemia counselling.

There was no significant correlation between BMI (p>0.05) and haemoglobin levels (Graph 1). A significant correlation between BMI to haemoglobin level was observed (β = -0.550, *R-square* = 0.054, p<0.01) after adjusting for body fat factor in a multiple linear regression (Graph 2). Body mass index demonstrated a weak negative correlation with haemoglobin levels in adolescent girls. Although R^2 is only 5,4%, this does not imply that it is meaningless. It is dependent on the field of study. Learning about hemoglobin levels in adolescent girls, which have a wide range of influencing factors, will make it very difficult to obtain r-squared values much higher (Penn State Science, 2023).

DISCUSSION

This study demonstrated that BMI has a weak negative correlation with haemoglobin levels in adolescent girls. This finding confirmed a study in India that discovered a negative correlation between body mass index and haemoglobin levels (Acharya et al., 2018), as well as other studies showing that adolescent girls with overweight are more at risk for anaemia (Eftekhari et al., 2009). The samples in these studies are all adolescent girls.

This result is different with the result of research on Korean adolescents which observed that BMI is positively correlated with haemoglobin level (Jeong et al., 2022). The Korean study included boys and girls aged 10-18 years old. The current study is also different with the research on women aged 15-49 years old in Bangladesh which found that the risk of anaemia was higher in underweight women and decreased in obese/overweight women when compared to normal women. (Kamruzzaman, 2021). The difference in results could be due to the fact that Korean and Bangladesh studies used a broader range of age and gender of respondents than this study, which only included adolescent girls aged 10 to 18 years.

The contradictory results of several studies studying the relationship between body mass index and haemoglobin levels could be influenced by variances in the growing phase among study participants. Late adolescence differs from early and middle adolescence in the puberty process, including the growth spurt and body fat growth pattern. Furthermore, male and female body fat growth rates differ. There is a different pattern in the development of percent body fat between girls and boys. The addition of body fat for female adolescents increased significantly, in contrast to male adolescents who tended to experience a decrease in body fat. (Rodríguez et al., 2005). The process of puberty, including the growth spurt, moving from childhood to adolescence, affects body fat. These are due to the presence of puberty development factors such as breast growth and so on in teenage girls. Increases in skinfold thickness and lean body mass (LBM) are all physiologically related to increases in haemoglobin, hematocrit, and total iron binding capacity (Micozzi et al., 1989).

Some OV/OB adolescents (22.0%) have anaemia in this study, it might be due to the presence of fat accumulation in body fat. This fat accumulation can interfere with iron absorption (Hilton et al., 2023). Iron Deficiency Anaemia (IDA) is common in adolescents with overweight/obesity. Some studies have found that anaemia in overweight/obesity is not caused by a lack of iron intake or lower food security in the households of adolescent girls (Jones et al., 2017). There are no differences between normal weight and overweight/obesity in iron heme intake, non-heme intake, or other nutrients that influence iron absorption, even iron intake is higher in obese adolescent girls than in normal adolescent girls (Hendarto et al., 2018).

A study involving 62 healthy and non-anaemic women found that iron absorption in overweight/obese women is only two-thirds that of normal-weight women (Cepeda-Lopez et al., 2015). The mechanism underlying the increased risk of anaemia in overweight/obesity remains unknown. Possible causes include dilutional hypoferremia, inadequate iron intake, increased iron requirements, and impaired iron absorption in overweight/obese adolescents because of inflammation (Yanoff et al., 2007).

The strength of the current study is this study's data is primary, which means we have complete control over the study design and measurement technique. Aside from that, our use of BIA to estimate percent body fat (PBF) measurements may not introduce a significant bias, as evidenced by studies showing that the bias in BIA measurement versus dual-energy X-ray absorptiometry (DXA) is minor, whether in European or Asian population (Carpenter et al., 2013).

Due to practical constraints, this study cannot provide a comprehensive measure of the effect of BMI to haemoglobin levels. Our work has some limitations that should be considered in future research. First, haemoglobin, the only haematological biomarker, was used without taking into account other biomarkers such as serum ferritin, iron, and inflammatory biomarkers such as hepcidin, CRP, and others. As a result, it is difficult to explain differences in different study findings regarding anaemia prevalence, haemoglobin level, or iron level across obese and underweight individuals.

Second, the number of underweight and overweight/obese adolescent girls was lower, which may provide an issue in determining the correlation between body mass index and haemoglobin levels among adolescent girls. As a result, the current study emphasizes the importance of include numerous anaemia indicators in future studies in order to solve those constraints and properly explain the relationship. In addition, with a small sample size, these results need to be interpreted with caution.

CONCLUSION

In conclusion, our study on adolescent girls found that there is a weak negative correlation between BMI and haemoglobin levels after adjusting for body fat. The current study emphasizes the importance of additional research that includes several haematological and inflammatory biomarkers to better understand the complex relationship between body mass index and haemoglobin level, which is still controversial.

Acknowledgements

The authors would like to express their gratitude to Institute for Research and Community Services of Universitas Esa Unggul for the grant, and the Tangerang Public Health Office and Pasar Kemis Public Health Center for the support.

Conflict of interest

Authors have no conflicts of interest to disclose.

References

Commented [NN14]: One reference about overweight prevalence (which has just added in the main text) was completed here

Acharya S, Patnaik M, Mishra S, & Panigrahi A (2018). Correlation of hemoglobin versus body mass index and body fat in young adult female medical students. *National Journal of Physiology, Pharmacy and Pharmacology* 8(9): 1371-1373.

ACON Laboratories Inc. (2023). *Mission® Hemoglobin*. From https://www.aconlabs.com/brands/mission/mission-hemoglobin/. [Retrieved September 25 2023].

Adiyani K, Heriyani F, & Rosida L (2020). Relationship between nutrition status and the incidence of anaemia in adolescent Girls at Senior High School PGRI 4 Banjarmasin, *Homeostasis* 1(1): 1-7.

Carpenter CL, Yan E, Chen S, Hong K, Arechiga A, Kim WS, Deng M, Li Z & Heber D (2013). Body fat and body-mass index among a multi-ethnic sample of college-age men and women. *Journal of Obesity* 2013:790654.

Cepeda-Lopez AC, Melse-Boonstra A, Zimmermann MB, & Herter-Aeberli I (2015). In overweight and obese women, dietary iron absorption is reduced and the enhancement of iron absorption by ascorbic acid is one-half that in normal-weight women. *American Journal of Clinical Nutrition* 102(6): 1389–1397.

Deurenberg P, Andreoli A, Borg P, Kukkonen-Harjula K, De Lorenzo A, Van Marken Lichtenbelt WD, Testolin G, Vigano R & Vollaard N (2001). The validity of predicted body fat percentage from body mass index and from impedance in samples of five European populations. *European Journal of Clinical Nutrition 55*(11): 973–979.

Dua A, Aggarwal M & Sharma P (2021). Comparative study to evaluate the diagnostic performance of mission ultra Hb meter with haematology analyser i3 North Indian teaching hospital-based study. *International Journal of Clinical and Diagnostic Pathology* 4(4): 86-89.

Eftekhari MH, Mozaffari-Khosravi H & Shidfar F (2009). The relationship between BMI and iron status in iron-deficient adolescent Iranian girls. *Public Health Nutrition* 12(12): 2377-81.

Enggardany R, Hendrati LY & Hairi NN (2021). Relationship between Body Mass Index (BMI) and Anaemia Among Adolescent Indonesian Girls (Analysis of The Indonesia Family Life Survey 5th Data). *Amerta Nutrition* 5(4): 347-352.

Handari SRT, Anies KMI & Nugraheni SA (2022). Haemoglobin Level of Pregnant Women was Associated with History of Anaemia During Adolescent Period: Findings from the Indonesia Family Life Survey. *Bali Medical Journal* 11(3): 1710-1716.

Handayani & Novayelinda J (2016). Relationship between nutrition status and the incidence of anaemia in adolescent girls. *Online Journal of College Students* 2(1): 310–316.

Harahap AP, Pamungkas CE, Amini A & Nopitasari N (2019). Relationship between body mass index and the incidence of anaemia in female adolescents at Public Junior High School 14 Mataram. *Indonesian Midwifery Research Journal* 3(1): 33-36.

Hendarto A, Febriyanto R & Kaban RK (2018). Iron deficiency and iron deficiency anaemia in obese adolescents. *Sari Pediatri* 20(1): 1-6.

Hilton C, Sabaratnam R, Drakesmith H & Karpe F (2023). Iron, glucose and fat metabolism and obesity: an intertwined relationship. *International Journal of Obesity* 47: 554 – 563.

Indonesian Ministry of Health (2018). *Main Results of Basic Health Research 2018*. From https://www.litbang.kemkes.go.id/hasil-utama-riskesdas-2018/. [Retrieved March 25 2023].

Irache A, Gil P & Caleyachetty R (2022). The co-occurrence of overweight/obesity and anaemia among adult women, adolescent girls and children living in fifty-two low- and middle-income countries. *Public Health Nutrition* 25(6): 1595–1606.

Jeong HR, Lee HS, Shim YS & Hwang JS (2022). Positive Associations between Body Mass Index and Hematological Parameters, Including RBCs, WBCs, and Platelet Counts, in Korean Children and Adolescents. *Children* 9(1): 109.

Jones AD, Mundo-Rosas V, Cantoral A & Levy TS (2017). Household food insecurity in Mexico is associated with the co-occurrence of overweight and anaemia among women of reproductive age, but not female adolescents. *Maternal and Child Nutrition* 13(4): e12396.

Kamruzzaman M (2021). Is BMI associated with anaemia and hemoglobin level of women and children in Bangladesh: A study with multiple statistical approaches. *PLoS ONE* 16(10): e0259116.

Lee PH & Burstyn I (2016). Identification of confounder in epidemiologic data contaminated by measurement error in covariates. *BMC Medical Research Methodology* 16(1):1-18

Liberali R, Kupek E & Assis MAA De (2020). Dietary Patterns and Childhood Obesity Risk: A Systematic Review. *Childhood Obesity, 16*(2): 70-85.

Lo SK, Li IT, Tsou TS & See L (1995). Non-significant in univariate but significant in multivariate analysis: a discussion with examples. *Changgeng Yi Xue Za Zhi* 18(2):95-101.

McCarthy HD, Cole TJ, Fry T, Jebb SA & Prentice AM (2006). Body fat reference curves for children. *International Journal of Obesity* 30(4): 598-602.

Micozzi MS, Albanes D & Stevens RG (1989). Relation of body size and composition to clinical biochemical and hematologic indices in US men and women. *American Journal of Clinical Nutrition* 50(6): 1276–1281.

Mrimi EC, Palmeirim MS, Minja EG, Long KZ & Keiser J (2022). Malnutrition, anaemia, micronutrient deficiency and parasitic infections among schoolchildren in rural Tanzania. *PLoS Neglected Tropical Diseases* 16(3): e0010261.

Mulyani R, Lupiana M & Yunianto AE (2021). Risk factors of anaemia in obesity adolescent girls in Bandar Lampung. *Prime Nutrition Journal* 6(1): 66-74.

Oddo VM, Maehara M & Rah JH (2019). Overweight in Indonesia: An observational study of trends and risk factors among adults and children. *BMJ Open* 9(9): e031198.

Olatunya OS, Olu-Taiwo A, Ogundare EO, Oluwayemi IO, Olaleye AO, Fadare JO, Adekoya-Benson T, Fatunla O, Agaja OT, Omoniyi E & Oluwadiya KS (2016). Evaluation of a portable haemoglobin metre performance in children with sickle cell disease and implications for healthcare in resource-poor settings. *Journal of Tropical Pediatrics* 62(4): 316-323.

Penn State Science (2023). *The Coefficient of Determination, r-squared*. Pennsylvania State University. From https://online.stat.psu.edu/stat462/node/95/. [Retrieved September 24 2023].

Rachmi CN, Li M & Alison Baur L (2017). Overweight and obesity in Indonesia: prevalence and risk factors—a literature review. *Public Health* 147:20-29.

Kliegman RM & St. Geme J (2020). *Nelson Textbook of Pediatrics 2-Volume Set, 21st Edition*. Elsevier/Saunders. Philadelphia.

Rodríguez G, Moreno LA, Blay MG, Blay VA, Fleta J, Sarría A & Bueno M (2005). Body fat measurement in adolescents: Comparison of skinfold thickness equations with dual-energy X-ray absorptiometry. *European Journal of Clinical Nutrition* 59(10): 1158-1166.

Sahoo J, Epari V, Panigrahi S, Prasad D, Bhola R, Mohanty S & Behera B (2021). Challenges in detection of adolescent anaemia: Validation of point-of-care device (Mission® plus) for haemoglobin measurement among tribal residential school children of selected districts of Odisha, India. *Indian Journal of Community Medicine* 46(4): 680-684.

Sandy YD, Tamtomo DG & Indarto D (2021). The Relationship between body weight and the incidence of anaemia in adolescent girls in Boyolali Regency. *Journal of the World of Nutrition 3*(2): 94-98.

Sari P, Herawati DMD, Dhamayanti M & Hilmanto D (2022). Anaemia among Adolescent Girls in West Java, Indonesia: Related Factors and Consequences on the Quality of Life. *Nutrients 14*(18): 3777.

Syah MNH (2022). The Relationship between obesity and anaemia among adolescent Girls. *Poltekita, Journal of Health Sciences*, *15*(4): 355–359.

Tegegne KT, Tegegne ET, Tessema MK & Assef AA (2021). Association of Parasitic Infection and Anaemia in Pregnant Women in Ethiopia- A Systemic Review and Meta-analysis. *Journal of Tropical Disease and Public Health 9*(8): 1-6.

World Health Organization (2015). *Iron deficiency anaemia: assessment, prevention and control*. From https://www.who.int/publications/m/item/iron-children-6to23--archived-iron-deficiency-anaemia-assessment-prevention-and-control [Retrieved April 25 2023].

Yanoff LB, Menzie CM, Denkinger B, Sebring NG, McHugh T, Remaley AT & Yanovski J A. (2007). Inflammation and iron deficiency in the hypoferremia of obesity. *International Journal of Obesity* 31(9): 1412-1419.

Zeleke MB, Shaka MF, Anbesse AT & Tesfaye SH (2020). Anaemia and Its Determinants among Male and Female Adolescents in Southern Ethiopia: A Comparative Cross-Sectional Study. *Anaemia 2020*:3906129: 1-10.

Table 1. Distribution of adolescent girls according to sociodemographic characteristics and nutrition status (*n*=171)

Characteristics			Haemoglobin (g/dL)		
		n (%)	*Mean*	*SD*	*p**
Haemoglobin level		171(100.0)	13.1	1.5	-
Anaemia status	Normal	137 (80.1)	13.1	1.5	-
	Anaemia	34 (19.9)	10.9	0.9	
Age, *mean (SD), years*		13.7 (1.5)			-
Age range	Early	77 (45.0)	13.0	1.4	0.331
	Middle	87 (50.9)	13.1	1.5	
	Late	7 (4.1)	13.1	1.6	
BMI/age, *mean (SD), z-score*		0.1 (1.4)			-
Nutrition status	Thinness/severe thinness	9 (5.3)	13.0	1.5	0.683
	Normal	121 (70.8)	13.4	0.9	
	Overweight/obesity	41 (23.9)	13.1	1.3	
Body fat, *mean (SD), %*		27.5 (8.6)			-
Percent body fat level	Normal	131 (76.6)	13.0	1.5	0.509
	Overfat	40 (23.4)	13.2	1.2	
Menarche age, *mean (SD), year*		11.6 (0.9)			
Menstrual status	No	5 (2.9)	13.6	0.9	0.417
	Yes	166 (97.1)	13.0	1.5	
Mother's education	Low	67 (39.2)	13.0	1.4	0.651
	High	104 (60.8)	13.1	1.5	
Father's education	Low	52 (30.4)	13.1	1.4	0.979
	High	119 (69.6)	13.1	1.5	
Number of household members, *mean (SD), person*		4.3 (1.2)			
Household size	Small	103 (60.2)	12.9	1.5	0.360
	Moderate	59 (34.5)	13.2	1.4	
	Big	9 (5.3)	13.3	1.7	
Having received counselling on anaemia	Never	124 (72.5)	13.0	1.5	0.313
	Ever	47 (27.5)	13.2	1.4	

Age range: early (10-13 years), middle (14-17 years), and late (18-21 years; Nutrition status: thinness/severe thinness (<-2.01 *SD*), normal body weight (-2.00 *SD* to +1.00 *SD*), and overweight/obesity (>+1.01 *SD*); Classification of percent body fat is based on age-specific cut off from the body fat reference curves (McCarthy et al., 2006). Education: low (< senior high school) and high (≥ senior high school); Household size: small (≤4 people), moderate (5-6 people), big (≥7 people); *Independent *t*-test and one-way ANOVA.

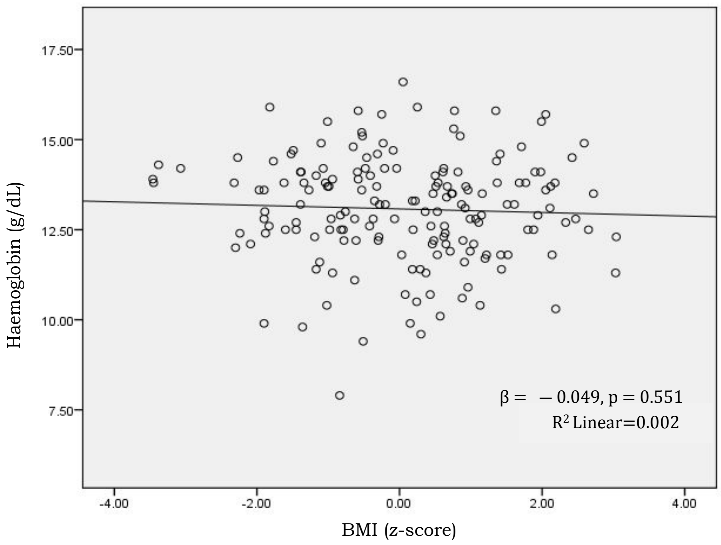

Figure 1. The correlation between body mass index and haemoglobin levels among adolescent girls

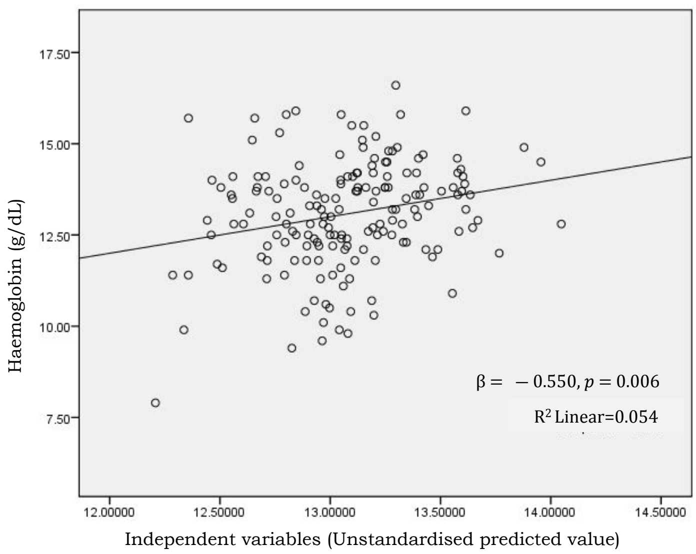

Figure 2. Multiple linear regression of the body mass index and and haemoglobin levels after adjusted by body fat in adolescent girls.