

Profile of nutritional status, energy availability, haemoglobin levels and bone density in *santriwati* (Islamic female student) with chronic energy deficiency risk

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ABSTRACT

Background: Santriwati (Islamic female student), women of reproductive age, were susceptible to experienced Chronic Energi Deficiency (CED). CED reflects the low energy availability of someone who can risk reducing bone density. **Objectives:** This study aimed to analyze the differences in body mass index, body fat percentage, hemoglobin levels, energy availability, and bone mineral density of female students who experienced CED risk and not experienced CED risk.

Materials and Methods: The research design was a cross-sectional study, with 101 female students as subjects who were selected by random sampling. The research was conducted from February to March 2019 at the Kyai Galang Sewu Islamic Boarding School, Semarang. CED risk data was taken using the upper arm circumference measurement. Percent body fat and BMI data were taken using BIA. Energy availability data is obtained from the difference between energy intake (energy intake) and energy output (energy expenditure through physical activity) divided by Fat-Free Mass (FFM). Energy intake data was taken using the SQ-FFQ questionnaire, and energy expenditure was calculated using the 24-hour activity record form. Anemia data were collected using strip hemoglobin measurements. Bone density data were taken using the Osteosys Sonost 3000 densitometer. Bivariate analysis used the Independent T-Test.

Results: A total of 57.2% of subjects experienced anemia. Subjects who had underweight nutritional status were 20.8%. Santriwati experienced osteopenia as much as 13.9%. There was no difference in bone density and hemoglobin levels between female students who were at risk of CED and not CED risk ($p > 0.05$), but there were differences in energy availability, body fat percentage, BMI between those at risk of CED and not CED risk ($p < 0.05$)

Conclusion: subjects at risk of CED (Lila < 23.5 cm) had lower energy availability, body fat, and BMI than subjects who were not at risk of CED.

Keywords: Anemia; Body fat; BMI; Bone Density; CED risk; Santriwati

BACKGROUND

The number of women of reproductive age (WRA) in Indonesia has the largest number in Southeast Asia with 65 million.¹ Nutritional problem in WRA in Indonesia is still high. One of the nutritional problems that often occur in WRA is Chronic Energy Deficiency (CED). CED is a condition when a person suffers an imbalanced nutrient intake (energy and protein) that lasts for a long time.² The prevalence of CED risk on non-pregnant Indonesian women in 2018 based on the Mid-Upper Arm Circumference (MUAC) indicator is 14.5%.³ The prevalence of CED risk on WRA, 15-19 years old, has increased from 30.9% to

36.3%, and the risk on WRA 20-24 years old also increased from 28.2% to 23.3% in 2007-2018.³

One of the WRA groups in Indonesia that tends to have nutritional problems is *santriwati*, female students in Islamic schools. A study conducted at the Al-Hidayah Islamic Boarding School in Grobogan Regency showed that 51.1% of the students were malnourished caused by insufficient nutritional intake.⁴ Other research at Slafiyah Kauman Pemalang Islamic Boarding School also showed that 38% of *santriwati* were malnourished.⁵ Body Mass Index (BMI) is used as the indicator to assess the nutritional status, where the body weight (kg) is divided by the square of height (m^2). BMI is

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a valid predictor and is widely used around the world.⁶

Another nutrition issue that always occurs in santriwati is anemia. Studies conducted in Islamic Boarding Schools in Indonesia showed that some Santriwati have low hemoglobin. For example, is in Husada Islamic Boarding School, 83.90% of santriwati experience anemia.⁷ In Darul Ulum Peterongan Jombang Islamic Boarding School showed that 57.5% of santriwati had anaemia.⁸ The malnutrition and low hemoglobin status of santriwati were usually caused by low food intake both in quantity and quality, for example, is the research that was conducted in Kepung Kediri observed a difference between teenage girls who lived in boarding schools than at home. The study showed that more teenage girls who lived in boarding schools experienced anemia due to the lack of knowledge, parental control and the ability to provide healthy food.⁹

The low energy reserves and nutrients can cause CED in WRA during adolescence may continue to pregnancy and breastfeeding.¹⁰ Energy availability represents the remaining energy in the body or energy reserves for metabolic processes so that it can carry out the physiological function properly.

Energy availability is the difference between energy intake and energy expended during activity (relative to fat-free mass).¹¹ The energy availability value of 30 kcal/kg FFM /day is the threshold of energy availability required for physiological body functions.¹² Low energy availability usually occurs in athletes. They have a high energy expenditure and are often not compensated with adequate food intake to maintain their body weight.¹³

Aside from the abovementioned problems, a health problem that often arises in women of reproductive age is low bone density. Women were more likely to have a four-time risk of developing osteoporosis than men.¹⁴ Research conducted by Ria Stella on bone density in young adult women showed that nutritional status and body weight had a significant association with bone density. Low bone density was associated with a lower percentage of body fat in subjects, where the body fat mass produces estrogen for the formation of bone mass.¹⁵

Based on these backgrounds, the researchers were interested in examining the differences between body mass index, percentage of body fat,

hemoglobin levels, energy availability, and bone density in female students who are at risk for CED and those who are not at risk for CED.

MATERIALS AND METHODS

This study was conducted at Kyai Galang Sewu Islamic Boarding School, Semarang, in April 2019. This is an observational study with a cross-sectional design. The random sampling technique was used to select a total of 101 participants who fulfill the inclusion criteria. The inclusion criteria include, santriwati who were active at Kyai Galang Sewu Islamic Boarding School, did not suffer from infectious diseases (typhoid, chronic diarrhea, upper respiratory tract infections (URTI), TB, hepatitis, malaria, and dengue fever), did not consume any supplement or drug which may affect body composition, and willing to participate in this study.

For this study, the dependent variables are bone density, hemoglobin level, energy availability (EA), BMI, and body fat percentage. In comparison, the independent variable is chronic energy deficiency (CED) status, which is classified into at risk (CED group) and not at risk (normal group) of CED. The CED status was determined by measuring the participants' mid-upper arm circumference (MUAC) using MUAC tape. The measurement was performed on the left arm. For left-handed women, their right arm was measured. Wearing clothes as thin as possible, and if possible, rolling up the sleeves until the acromion is visible. Mark the acromion and the olecranon process, then mark the mid-point between these marks. Wrap a MUAC tape around the mid-point mark. The participants were categorized as at risk of CED if the mid-upper arm circumference is less than 23.5 cm.³

The bone density was measured using a densitometer from Osteosys Sonost 3000 with a quantitative ultrasound method. The bone density was normal if the T-score $-1 \leq SD < 2.5$, the participants were categorized as osteopenia if the T-score is $-2.5 \leq SD < -1$ and osteoporosis if the T-score was < -2.5 .¹⁶

The hemoglobin level was determined by the hemoglobin test strip. The assessment was carried out by drawing blood from the participants to stain the strip before putting the stained strip into a hemoglobin meter from the Hemocue brand. The normal hemoglobin for women is 12 g/dL; anemia is defined by the hemoglobin of less than 12 g/dL.⁷

The BMI is calculated as weight divided by the square of the height in meters. The participants' body height was measured using a microtoise or stature meter to an accuracy of 0.01 cm. The participants stood barefooted and bare of any accessory on their heads.¹⁷ The body weight was measured using a BIA Tanita DC 360 scale. The participants are categorized as underweight if the BMI was <18.5 kg/m², normal if the BMI was 18.5-24.9 kg/m², and overweight if the BMI was 25-29.9 kg/m²; and obese if the BMI was ≥30 kg/m².

To calculate the body fat percentage, a body composition measurement using BIA Tanita DC 360 was conducted. Previously, the result of the height measurement from the stature meter was put into BIA Tanita DC 360. Twenty-four hours before the data collection, participants were recommended to drink at least eight glasses of water in a day and avoid caffeine and alcohol to achieve good hydration status.¹⁸ The body fat percentage was classified into athletic (10-15%), good (16-19%), normal or acceptable (20-25%), overfat (26-29%), and obese (>30%).¹⁹

The energy availability was calculated from the difference between energy intake and energy

expenditure divided by fat-free mass (FFM). The energy availability status was classified into low EA (<30 kcal/kg FFM/day), good (30-45 kcal/kg FFM/day), and high (>45 kcal/kg FFM/day).²⁰ The energy intake was obtained by analyzing 24 hour-food recall 6x24 hours using Nutrisurvey 2007 application. During physical activities within 24 hours, the energy expenditure was calculated using the following formula: 3.5 x bodyweight x Basal Metabolic Rate x time.²¹ The fat-free mass was obtained from body composition measurement using BIA Tanita DC 360.

The univariate analysis was performed to describe each variable. The bivariate analysis using an independent t-test was performed to analyze the differences in bone density, hemoglobin level, BMI, body fat percentage, and energy availability among santriwati in the CED and normal groups. This study has been approved by the Health Research Ethics Committee (KEPK) Faculty of Medicine, Universitas Diponegoro and Central Public Hospital dr. Kariadi number 162/EC/KEPK/FK-UNDIP/V/2019.

RESULTS

Participants Characteristics

Table 1. Characteristics of participants

Variable	Median	Minimum	Maximum
Age (year)	20	18	24
Weight (kg)	46.7	32.9	67.5
Height (cm)	152.5	139	169.5
Body Mass Index (kg/m ²)	20	14	32
Mid-upper arm circumference (cm)	23.5	19	30.5
Body Fat Percentage (%)	27.3	16	44.9
Haemoglobin (g/dL)	11.6	6.3	15.1
Bone Density (T-Score)	-0.5	-1.6	1.8
Energy intake (kcal)	1300	28.5	815
Energy availability (kcal/kgFFM/day)	1.9	1	9.6

Table 1 shows the distribution of the participants' characteristics, namely BMI, body fat percentage, mid-upper arm circumference (MUAC), bone density, and hemoglobin level. Some participants recorded a BMI of 14, while others recorded 32 kg/m². By the same token,

the median hemoglobin level was 11.6 g/dL, but one of the participants recorded only 6.3 g/dL. The bone density among santriwati was relatively normal, although some recorded negative T-score, it was still within the normal range.

Table 2. Characteristics of participants based on nutritional status, anemia status, Chronic Energy Deficiency, and bone density

Category	n	%
Anemia Status		
Anemia	58	57.4
Normal	43	42.6
Chronic Energy Deficiency		
Risk	45	44.6
Normal	56	55.4
Body Fat Percentage		
Normal	68	67.3
Overfat	16	15.8
Obese	17	16.8
Body Mass Index for Age (BMI/U)		
Underweight	21	20.8
Normal	60	59.4
Overweight	11	10.9
Obese	9	8.9
Bone Density		
Normal	87	86.2
Osteopenia	14	13.9

Table 2 further displays the participants' characteristics. Based on hemoglobin assessment, 57.4% of the participants (n=58) were anemic. The nutritional status assessment using MUAC measurement reported 44.6% (n=45) participants were at risk of CED; meanwhile, 68.3% (n=68) had

normal body fat percentage. Nutritional status based on BMI showed that 20.8% (n=21) of the participants were underweight. Most of the participants had a normal bone density, but 13.9% (n=14) had osteopenia.

Table 3. Difference of bone density, haemoglobin levels, Chronic Energy availability, body mass index and body fat percentage between CED risk and normal groups

Variable	CED risk (n=45) Mean ±DS	Normal (n=56) Mean ±DS	P value
Bone Density (T-Score)	-0.48±0.5	-0.4±0.56	0.458 ^a
Haemoglobin Levels (g/dL)	11.29±1.75	11.48±1.95	0.61 ^a
Energy Availability (kcal/kgFFM/day)	1.77±0.78	3.98±2.74	<0.001 ^{a*}
Body Mass Index (kg/m ²)	18.68±1.47	22.16±2.83	<0.001 ^{a*}
Body Fat Percentage (%)	24.89±3.76	31.56±5.08	<0.001 ^{a*}

^a=Independent t-test *significant (p<0.05)

Based on table 3, there was a difference in energy availability between CED risk and normal groups (p<0.001). The mean of energy availability in the CED risk group was lower (1.77 kcal/kgFFM/day ±0.78) than the normal group (3.98 kcal/kgFFM/day ±2.74). Additionally, there was a difference in BMI between the normal and CED groups (p<0.001). The mean BMI in the CED group

was lower (18.68 kg/m²±1.47) than the normal group (22.16 kg/m²±2.83). There was a difference in body fat percentage between the normal and CED groups (p<0.001). The mean body fat percentage in the CED group was lower (24.89 (%±3.76) than the normal group (31.56 (%±5.08). However, there were no differences in bone density and hemoglobin

levels among the CED and normal groups ($p=0.458$; $p=0.61$)

DISCUSSION

The santriwati at Kyai Galang Sewu Islamic Boarding School also receive normal education where most of the santriwati were college students. Based on the analysis, 44.6% of the participants were at risk of CED, determined by the MUAC measurement. MUAC is considered practical to use in the field to assess the risk of CED.²² The study conducted at AL-Munawwir Islamic Boarding School Yogyakarta reported 26.7% of santriwati were at risk of CED.²³ Furthermore, most of the santriwati were anemic. Anemia among women of reproductive age may increase the risk of maternal death, low birth weight, prone to infection, miscarriage, and increase the risk of premature labor.²⁴ A report conducted at Salafiyah Syafi'iyah Islamic Boarding School Sukorejo, Situbondo, stated that 79% of the participants were anemic based on their hemoglobin level.²⁵ Nutritional status measurements based on BMI also indicated that 20.8% of participants in this study were underweight. Another study conducted at Al-Hidayah Islamic Boarding School, Grobogan District, reported that 51.1% of santri had low nutritional status.⁴

The Difference of BMI between Santriwati With and Without Risk of CED

There was a difference in BMI between the normal group and the CED group. It was indicated by the mean BMI in the CED group, which was lower compared to the normal group. Another study by Brito et al. supported this result with their report, which showed a significant association between MUAC and BMI. The lower the MUAC is, the lower BMI would be.²⁶ Another study in India registered a positive relation between MUAC and BMI among pregnant women.⁶ BMI measurement is the most common measurement of nutritional status. Yet, due to the needs of several tools and skills, other means of measurement, such as MUAC, may be used to determine women's nutritional status. This measurement is considered practical and gives an overview of women's nutritional status well.⁶ More articles showed an association between MUAC and BMI, which also explains the difference in BMI between santriwati with and without CED

risk. The BMI of the CED group was lower than the normal group.

The Difference of Body Fat Percentage between Santriwati With and Without Risk of CED

Based on the analysis, there was a difference in body fat percentage between the CED and normal groups. This finding is supported by another study in India that reported a significant association between BMI and body fat percentage. The lower the BMI score is, the lower the body fat percentage would be.²⁷ BMI also gives an overview of CED in women.²⁸ It may explain the difference in the mean body fat percentage between the CED and normal groups. The body fat percentage of the CED group was lower than the normal group.

The Difference of Energy Availability between Santriwati With and Without Risk of CED

Based on the analysis, there was a difference in energy availability between the CED and normal groups. The mean score of energy availability in the CED group was lower compared to the normal group. The energy status assessment, such as energy availability measurement, is an accurate and objective measurement that can also reflect CED's compensation compared to using only nutritional status assessment.²⁹ The energy availability refers to the amount of energy leftover and available for body function after the energy expended for physical activities is subtracted from the energy consumed.²⁰ Low energy availability among santriwati was mostly caused by low energy consumption. Low energy reserves and nutrients may increase the risk of CED.¹¹ Loucks stated that low energy availability might cause loss of muscle mass or fat mass in the body. If it continues for a prolonged time, then physiological function may be compromised.³⁰ CED's risk increases if the depletion of muscle mass develops continually without adequate energy intake.³¹

The Difference of Haemoglobin Level between Santriwati With and Without Risk of CED

Based on the statistical analysis, there was no significant difference in CED and normal groups' hemoglobin levels. It contrasts with Pramodya et al. at Kediri District's findings, which reported a significant difference in hemoglobin levels between students with and without CED.³² However, a report

by Dea Intartanti showed an insignificant association between nutritional status and anemia among female adolescents.³³ This may be since macronutrients (carbohydrate, protein, fat) intake is not the only affecting factor hemoglobin level. Micronutrient intake also affects the hemoglobin factor, it was reported that the micronutrient intake is relatively good in the said study.³³ Energy intake deficiency may cause anemia as the protein breakdown is no longer aimed at erythropoiesis (red blood cell production) but instead to produces energy or glucose.³² Another study by Wiraprasidi et al. at Lolak Public Health Centre also reported similar findings; there was an insignificant association between hemoglobin level and MUAC.³⁴

The Difference of Bone Density between Santriwati With and Without Risk of CED

A significant difference in bone density between CED and normal groups was not found based on the analysis. This finding supports a previous study by Ana Yuliah Rahmawati, which stated no significant association between BMI and bone density among participants.³⁵ Likewise, Shera Mutiara reported no significant association between nutritional status and bone density among female adolescents.¹⁹ Many factors influence bone density; one of them being protein intake. Adequate protein intake is necessary to maintain estrogen production, which regulates bone synthesis.¹⁵ However, the protein intake in both the CED and normal groups was relatively similar; this may justify bone density similarity in both groups. Another influencing factor is body fat percentage. A significant association between bone density and body fat percentage was reported in a previous study conducted in Bandung. The higher the body fat percentage, the lower risk of osteoporosis is. However, maintaining a body fat percentage in the normal range is recommended to prevent degenerative diseases.³⁶

CONCLUSIONS

Based on the hemoglobin level, 57.4% of santriwati had anemia. Nutritional status assessment based on MUAC showed that 44.6% of participants were at risk of CED. On the other hand, 67.3% of the participants had a normal body fat percentage. Santriwati with osteopenia accounted for 13.9% of

the total participants. There were significant differences in energy availability, BMI, body fat percentage between CED and normal groups. The mean scores in the CED group were lower than the normal group. Yet, there were no significant differences in bone density and hemoglobin levels between CED and normal groups.

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