ORIGINAL ARTICLE

Energy, Protein Intake and Mid-Upper Arm Circumference in Pregnant Women in Boyolali Regency, Indonesia

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ABSTRACT

Introduction: : Mid-Upper Arm Circumference (MUAC) of pregnant women is an indicator to assess the chronic energy deficiency (CED) in ensuring healthy outcomes in women and newborns. This research aims to analyze correlation between energy protein intake and MUAC of pregnant women. **Methods:** The design of this research was an observational cross-sectional study. The study population included a total of 164 pregnant women in second and third trimester in a Community Health Center in Indonesia. The samples were chosen by a simple random sampling technique. Energy and protein intakes were assessed by interviewing the subjects' meal intake in the past three months using the semi-quantitative Food Frequency Questionnaire (SQ-FFQ) form. MUAC of pregnant women was assessed using a measuring tape by a trained researcher. Pearson product-moment tests were applied to analyze correlation between energy intake, protein intake and MUAC. **Result:** Majority of pregnant women experienced energy and protein intake deficiency, 97.6% and 73.2%, respectively. CED was found to be 17.1%. There were correlations between energy intake and MUAC (p=0.0215, r=0.181), and between protein intake and MUAC (p=0.001, r=0.319) in pregnant women. **Conclusion:** This study discovered that majority of pregnant women suffer from lack of energy and protein intake. Effective community nutritional program is still needed as the effort to reduce prevalence of inadequate energy and protein intake and prevent the CED among the pregnant women.

Keywords: Energy Protein Intake, MUAC, Pregnant Women

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INTRODUCTION

The nutritional problem of pregnant women is a problem that should receive more attention in countries around the world, especially in low to middle income countries. Based on 2018 Global Nutrition Report, around 20 million babies were born low birth weight each year, 150.8 million were stunted (22.2%), and 50.5 millions were wasted (7.5%) (1). Research suggested undernutrition in pregnancy specified as low mid-upper arm circumference (MUAC) is associated with birth outcome (2). The MUAC has some advantages including simple measurement and calculation, inexpensive tool, a reliable and more suitable measurement for assessing nutritional status and screening the risk for adverse maternal outcomes in low-resources setting (3, 4).

In 2016, WHO recommended MUAC for assessing undernourished pregnant women and advised for the use of country-specific cut-off points for MUAC (5). A meta-analysis included 11 studies among pregnant women in 9 countries (Asia, Africa, America) showed the mean MUAC varied from 20.0 cm to 28.9 cm as the cut-off point (6). Meanwhile, the MUAC cut-off point used in a national survey by the Ministry of Health Indonesia was 23.5 cm and the pregnant women who had MUAC lower than 23.5 cm stated suffer from chronic energy deficiency (CED) (7). In Indonesia, the prevalence of CED among pregnant women is 6.5% to 12.3% in 2018 (8). Similarly, according to preliminary study the percentage of pregnant women with CED indicated by MUAC < 23.5 cm in a Community Health Center of Kemusu 2, Boyolali Regency, Central of Java, Indonesia increased from 6.8% to 12.2% in 2016.

There are several factors related to low MUAC including rural residency, low educational status of partners, low economic status of households, having multiple pregnancies, poor nutritional indicators (9), household food insecurity, increasing trimester of pregnancy, anemia, the lean season of recruitment, distance to the health clinic (2). Food intake and dietary diversity directly influence the malnutrition problem and CED

on pregnant women (10, 11). Mutalazimah & Rahayu (2019) supports this finding, stating that pregnant women's nutritional status consist of the consumption, absorption, and utilization of various macro and micronutrients (12). If the intake of energy and protein is less than the Requirement Dietary Allowance (RDA) level needed over a period of time, it could cause malnutrition in pregnant women (13). CED is highly correlated with the adequacy of protein intake indicated by MUAC < 23.5 cm (7).

Pregnant women need additional energy intake at least 300 kcal per day from energy requirements estimated 340-452 kcal per day on the second and third trimester; therefore, the intake of energy needs should be balanced by additional energy intake. A full-term pregnancy needs around 80,000 kcal energy intake for maternal and fetal metabolism, as well as for fetal and placental growth (14). The additional energy sources of pregnant women are usually contributed by macronutrients such as carbohydrates, protein, and fat (15). The additional protein intake for Indonesian RDA needs to be added by 20gram per day. The increasing protein intake in pregnant women needed for the growth of mother's and fetal tissue and placenta (16). The adequacy of a person's protein is influenced by body weight, age (in growth and development stage), and protein quality in food consumption pattern. There is an escalation of protein in pregnant women, with 40% of maternal protein enhance reflected by the fetus, placenta, and amniotic fluid that increase during pregnancy (17).

The intakes of macronutrient were strongly correlated with pregnant women's nutritional status (18). Their nutrition needs usually increase according to their gestational age and fetus' growth and development. Lack of protein could also cause maldistribution of nutrients in the body (19). With normal metabolism and well-distributed nutrients, the increase of pregnant women's body weight and MUAC could be maintained properly, based on the doctor's recommendation. In a review of 62 studies in low-and middle-income countries, Lee et al. (2012) found that imbalanced macronutrients and inadequate micronutrients intakes were two of common diet features among pregnant women in low-resources settings (20). Lack of energy and protein could cause CED which is linked with increased risk of maternal anemia, mortality, morbidity, and adverse birth outcomes (21).

The availability of information on the energy and protein intakes and the linkage with CED in pregnant women is still limited in Indonesia, especially in several areas in low-resources settings. Therefore this research aims to analyze the correlation of energy and protein intake and MUAC in pregnant women in a Community Health Center of Kemusu 2, Boyolali Regency, Central of Java, Indonesia. It is expected that a better understanding of energy and protein intakes and MUAC of pregnant women will arrange awareness for improving maternal nutrition program development in low-resource settings.

MATERIALS AND METHODS

The research was approved by the Ethics Committee of the Faculty of Medicine, Universitas Muhammadiyah Surakarta with ethical clearance number: 375/B.1/KEPK-FKUMS/X. This research was categorized as observational study with a cross sectional design. The total population of pregnant women in their second and third-trimester pregnancy who lived in the surrounding areas of Community Health Center Kemusu 2 in a rural area of Boyolali Regency, Central Java, Indonesia were 326. Based on a minimum sampling size calculation, this study involved 164 samples were chosen by a simple random sampling technique using computerized randomization. These pregnant women have met the inclusion criteria which were not suffering any chronic or infection disease and metabolic disorder.

The variables used in this study were energy and protein intake as independent variables and MUAC as the dependent variable. The measurement of MUAC on pregnant women is an indicator to discover CED or starvation, especially who live in poor socio-economic and environments that have limited access to adequate nutritional intake, therefore they tend to have smaller amounts of subcutaneous fat. MUAC is commonly indicator used to assess nutritional status and determine eligibility for services among adults, especially in pregnant women (7).

The data on energy and protein intake were collected by in-depth interview technique using Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) form and applied food model equipment. The 24-hour interviews were conducted three times, once in every week for each respondent (non-consecutive), to anticipate the within variance in food intake (22). The consumed daily-basis energy and protein intake data were analyzed by using Nutrisurvey software, indicated in gram and then were compared to Recommended Dietary Allowances (RDA), and stated in percentage. The technique to acquire MUAC data was conducted by measuring pregnant women's mid-upper arm circumference by using MUAC tape (it was considered as normal nutrition status if MUAC is ≥ 23.5 cm and it was CED if MUAC is < 23.5 cm). The MUAC measurements were conducted and led by a senior nutritionist and were assisted by trained researchers.

It is well reported in various references (23), that women have a different risk of pregnancy and childbirth based on their age group. For descriptive analysis, the respondents in this study were divided into two age groups: <20 years old or >35 years old (at-risk pregnancy) and >=20 years old or <35 (not at-risk pregnancy). The physiological condition of women <20 years old were that the body are still on growth stage; the reproduction

organs are not well-developed and immature to be fertilized. Both <20 and >35 years old women are at increased risk for miscarriage, bleeding, and lack of nutrition. Percentage pregnant women with 35 years old and older who experienced some kind complication is 77.7% and strongly associated with premature birth (24). Education level of pregnant women categorized into lower education (elementary and junior high school or 6-9 years of school) and higher education (senior high school above or ≥ 12 years of school). The criteria of monthly household income in this study identified based on the regional minimum wage 2016 in Boyolali Regency is 1.403.500 rupiahs.

The data about the dietary diversity obtained by measure the consumption of 9 groups of foodstuffs (whole grains; roots and tubers; animal source foods; oils and fats; oily fruit/seeds; nuts; sugar; vegetables and fruits; and others: beverages and spices) during past seven days (25). The dietary diversity categorized "good" if the consumption of food at least consist of 5 groups of foodstuffs completely are whole grains or roots and tubers (the main source of carbohydrate); animal source foods (the main source of protein from animals); oils and fats (the main source of fat); nuts (the main source of protein from plants); and vegetables and fruits (the main source of vitamins and minerals), and otherwise categorized "poor".

Energy, protein, carbohydrate and fat intake levels of the pregnant women in the current study were categorized into three groups; the categorization is based on nutritional adequacy compared to RDA based on Indonesian Community Food and Nutrition, which separated into three categories: inadequate (<80%), adequate (80-110%), and excessive (>110%) (18). The additional requirements of energy, macronutrients and micronutrients needed during pregnancy for improve maternal nutritional status and birth outcome (16).

Univariate analysis was conducted to describe the frequency of each variable, which included energy intake, protein intake, and MUAC. The normality tests of the data were done by the Kolmogorov-Smirnov test. All data were normally distributed (protein intake p=0.209; energy intake p=0.518; MUAC p= 0.133) and then tested using Pearson's Product Moment. Simple and multiple linear regression were conducted to analyze the contribution and prediction energy and protein intake to the MUAC of pregnant women.

RESULTS

Subject's Characteristic

The subjects' characteristics are shown in Table I. This study found that 19.5% of pregnant women were at at-risk age group for pregnancy. Majority of pregnant women had low education level (finished 6-9 years of school), in the third trimester of pregnancy stage, and unemployed. The monthly household income majority lower than the minimum wage, and the majority of dietary diversity is poor category. There were very high percentage of pregnant women who categorized into energy, protein and fat intake deficiency; even all of pregnant women suffer from lack of carbohydrate intake. This study observed that 17.1% of pregnant women had MUAC < 23.5 cm.

Table I: The characteristics of study participants

Subjects' Characteristics	n (%)
Age	
At-risk (<20 and >35 years old)	32 (19.5)
Not at-risk (20-35 years old)	132 (80.5)
Education level	
Low (6-9 years of school)	120 (75.6)
High (≥12 years of school)	44 (24.4)
Stage of pregnancy	
Second trimester	61 (37.2)
Third trimester	103 (62.8)
Respondents Occupation	
Employed	73 (44.5)
Unemployed	91 (55.5)
Monthly household income	
< Minimum wage (1.403.500 rupiahs)	115 (70.1)
≥ Minimum wage (1.403.500 rupiahs)	49 (29.9)
Dietary Diversity	
Good	24 (14.6)
Poor	140 (85.4)
Carbohydrate intake	
Inadequate	164 (100)
Adequate	-
Excessive	-
Fat intake	
Inadequate	148 (90.2)
Adequate	16 (9.8)
Excessive	-
Energy intake	
Inadequate	160 (97.6)
Adequate	4 (2.4)
Excessive	-
Protein intake	
Inadequate	120 (73.2)
Adequate	44 (26.8)
Excessive	-
MUAC	
Normal	136 (82.9)
CED	28 (17.1)

Table II shows that the mean percentage of meeting RDA for energy intake, protein, carbohydrate and fat of pregnant women indicated lower than national standard for energy and macronutrient intake in Indonesia with cut-off point is 80%. The mean intake of energy and all macronutrients also lower than RDA for pregnant women. The mean of MUAC of all respondents is 26.05 cm ± 2.91 cm.

Correlation between energy, protein intake and MUAC

Pearson's Product moment test showed that there

Table II: Mean MUAC, energy, protein, fat intake and mean percentage of meeting RDA in pregnant women

Variable	Mean	SD	Min.	Max.
Energy intake (kcal)	1349.14	285.60	908.53	2174.26
Protein intake (gram)	48.04	14.14	24.40	78.96
Carbohydrate (gram)	143.97	38.29	88.97	245.02
Fat intake (gram)	44.38	14.05	21.06	80.10
Energy (%RDA)	56.38	11.18	35.62	85.27
Protein (%RDA)	65.85	18.31	32.11	103.89
Carbohydrate (%RDA)	40.55	10.78	25.06	69.02
Fat intake (%RDA)	54.05	17.48	25.49	94.23
MUAC (cm)	26.05	2.91	19.50	32.11

were correlations between energy intake and MUAC (p=0.0215, r=0.181), as well as between protein intake and MUAC (p=0.001, r=0.319) in pregnant women. Simple linear regression analysis showed that energy intake significantly predict the MUAC among pregnant women (p=0.021; R Square = 0.033 (energy intake affected the MUAC as many as 3.33%); the regression equation is MUAC = 23.4 + 0.047 energy intake. Protein intake significantly predicts the MUAC among pregnant women (p=0.001; R Square = 0.102 (protein intake affected the MUAC as many as 10.2%); and the regression equation is MUAC = 22.7 + 0.051 protein intake. The multiple regression showed that energy and protein intake not significantly to predict the MUAC among pregnant women, because there is a high linearity between energy and protein intake (p=0.001).

DISCUSSION

This study finding showed lower percentage of pregnant women at-risk age of pregnancy compare to a research conducted by Ervinawati et al. (2018), which found 56.4% of at-risk age group women (<20 and >35 years old) (26). Pregnant women at the time of recommended reproduction age (20-35 years old) will have a smaller likelihood of experiencing complications compared to those who are younger or above recommended reproductive age (27).

Research suggests that educational level has a consistent positive effect on nutrition intake. Women with low education level tend to have higher possibility to suffer from lack of nutrition and women with advanced education level have better food consumption pattern if compared to less-educated women (28). According to Stravik et al. (2019), educational level was the strongest factor that correlated to nutrient intake among woman (29). Pregnant women who have a higher level of education was positively correlated to nutrient intakes, both macronutrients (carbohydrate, protein and fat) and micronutrients (vitamins and minerals) (29,30). The research conducted by Nurdin et al. (2018) investigated that education level in pregnant women is significantly associated with CED (30).

This study found a very high percentage of pregnant women suffer from energy deficiency (97.6%), protein deficiency (73.2%), carbohydrate deficiency (100%) and fat deficiency (90.2%). This result almost similar with Wiyono's et al. (2020) study that revealed high percentage of pregnant women suffer from energy, protein, carbohydrate and fat intake deficiency (77.7%; 70.7%; 60.7% and 78.4%, respectively) (31). This conditions were directly caused by the fact that most pregnant women experienced lack of dietary diversity and adequacy of food intake. Socioe-conomic factors significantly associated with inadequate nutrient intake (28), this study revealed that majority of pregnant women were unemployed (55.5%) with monthly family income lower than minimum wage (70.1%) and these conditions may influence their dietary diversity.

Based on dietary diversity, the majority of pregnant women in this study (84.5%) suffer from poor dietary diversity, this finding higher than Diddana's study (2019) that found 54.8% pregnant women categorized poor dietary diversity (11). Pregnant women with poor dietary diversity in this study, they were not consume food that consisting of at least 5 groups from 9 groups of food completely. Most of pregnant women not consume animal source foods, and some pregnant women not consume vegetables and fruits. The majority of food groups that be consumed by pregnant women are the group of whole grains (rice, wheat, noodle); oils and fats (palm oil); nuts (soybean, tofu, and "tempe"/ fermented soybean); sugar (sugar and brown sugar); vegetables and fruit (cabbage, mustard green, carrot, and banana). There are some pregnant women who consume animal foods, they consume poultry eggs and salted fish more frequently, while beef, chicken, and seafood are rarely consumed. Therefore makes pregnant women experienced lack of dietary diversity. A lack of dietary diversity caused energy and macronutrients inadequacy in women of reproductive age (32), as well as micronutrients intake deficiency and correlated with anthropometry measures (33), and there is a strong correlation between dietary diversity and MUAC in pregnant women (11, 35).

This study discovered that mean percentage of meeting RDA for energy (56.38%), protein (65.85%), carbohydrate (40.55%) and fat intake (54.05%) were considered as inadequate (<80%), almost similar with Patimah's et al. (2011) study that the mean percentage of meeting RDA for energy and protein intake is 59.16% and 72.26% (35). Similarly, the mean intake of energy (1349.14kcal±285.60), protein (48.04gram±14.4), carbohydrate (143.97gram±38.29) and fat (44.38gram±14.05) are extremely lower than Indonesian's RDA for pregnant women that standardized intake of energy, protein, carbohydrate and fat is

2850kcal; 77gram; 373gram; and 70gram, respectively. Based on the comparison of mean intake of energy and macronutrient and the RDA, this study indicated that intake of energy and macronutrient in pregnant women categorized into inadequate intake.

This study observed that 17.1% of pregnant women with MUAC < 23.5 cm, which is lower than research conducted by Nurdin et al. (2018) in Jeneponto Regency, Southern Sulawesi, Indonesia which found 23.1% (30), and almost similarly with Willy's et al. study (2016) that discovered pregnant women with low MUAC is 19.3% (34). The mean value of MUAC in this study (26.05 cm) also in accordance with a previous research that finds the mean value of MUAC in pregnant women is 26.7 cm (30). Both energy and protein intake in inadequate category increase the risk of low MUAC that indicated CED during pregnancy (7).

Optimizing nutritional status before, during, and after pregnancy is important for mothers, both in short-term and long-term situation. Pregnant women should have enough energy, both in the nutritional supply from diet and the reservation for maintaining health for herself and the baby and for lactation (36). Energy intake is acquired from food consumption derived from carbohydrates, protein, and fat to produce energy (ATP), which is acquired from metabolism process as energy source for body organ activities. Energy intake is one of the factors to maintain pregnant women's nutritional status, which will increase according to the gestational age.

This study found a correlation between energy intake and MUAC; and between protein intake and MUAC in pregnant women. This finding is in line with a research conducted by Rahmawati et al. (2019) that discovered a significant relationship between food consumption patterns, especially energy and protein intake with MUAC (10). Low MUAC in pregnant women that indicates CED is a nutritional problem that occurs in a long time. According to this study, a positive correlation of these variables indicates that the greater intake of energy and protein will improve the nutritional status of pregnant women as well as vice versa. These CED events are associated with inadequate energy intake (97.6%). This CED event describes the state due to lack of energy or imbalance of energy intake to meet the needs of the body (37).

The linkage CED with protein intake explained that protein is one of macronutrients that has important role for metabolic processes of the body's nutrients, especially for transporter, enzyme former, and alternative energy source. Lack of protein intake could cause amino acid and mineral deficiency resulting in decreased body immune to diseases and decreased muscle mass. This is in accordance with the principle of a person's nutrition intake and nutritional status; if a pregnant woman has good dietary diversity including adequate protein intake, the nutritional status will also be improved (11). By consuming foods with high protein could boost the optimum absorption ability to maintain and increase muscle mass (38). Inadequate protein intake reduces energy digestion, causes hyperphagia and thermogenesis and loss lean mass and body weight (39). Other studies state that there is a correlation of protein intake variable in predicting CED cases on pregnant women (10).

The limitation in this cross-sectional study there is no pre pregnancy data (nutrient intake and nutritional status), thus it cannot be described whether the condition of CED during pregnancy is related to past nutritional status. Future cohort studies are needed to clarify this findings. The other limitation of this cross-sectional study is the data on dietary diversity and food intake may vary over time.

CONCLUSION

It can be concluded that there is a correlation between energy intake and MUAC as well as between protein intake and MUAC on pregnant women. The magnitude of pregnant women who suffer from energy and protein deficiency is high. There is a need to design and implement programs and strategies using nutritional education and supervision to reduce the risk of CED on pregnant women.

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