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The Relationship between Mid Upper Arm Circumference and Newborn Anthropometry Outcomes in West Sumatera, Indonesia

Hubungan Status Lingkar Lengan Atas Ibu Hamil dengan Antropometri Bayi Baru Lahir di Sumatera Barat, Indonesia

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ABSTRACT

Background: Mid-upper Arm Circumference (MUAC) during pregnancy is used to determine Chronic Energy Deficiency (CED). Pregnant women with CED are at risk of giving birth with Low Birth Weight (LBW), short, and wasting babies. Data from the West Sumatra Health Office show that the number of women suffering from continues to increase. The percentage of LBW per 1000 live births is also high and has not decreased significantly.
Objectives: To determine the relationship between MUAC and newborn anthropometry outcomes in West Sumatera, Indonesia.
Methods: This research used secondary data from the VDPM Cohort Study with 184 pairs of mothers and babies. The variables taken in this study were MUAC, Birth Weight (BWG), Birth Body Length (BLG), Birth Head Circumference (HDC), and Small for Gestational Age (SGA). Data analysis used descriptive analysis, Spearman Correlation, and Wilcoxon tests.
Results: There was a significant positive correlation between MUAC and the anthropometry of newborn babies (p-value<0.05, for all comparisons). The greater the MUAC, the greater the anthropometry outcomes. However, the correlation was weak. There was a significant relationship between MUAC and SGA (p-value≤0.001). Babies with appropriate gestational age (AGA) had normal MUAC status and women who had CED status most likely gave birth to a baby with an SGA status.
Conclusions: The MUAC status of pregnant women determines newborn anthropometry outcomes. Therefore, mothers can prepare for pregnancy by maintaining their health and nutritional status. Further studies are needed to confirm these findings.

INTRODUCTION

Pregnancy is an essential sign of the future quality of human resources. The fetus's condition during pregnancy is greatly influenced by maternal nutrition and health. Maternal nutrition and health have a significant impact on the baby's physical growth, cognitive development, and health potential in the future. A fetus with optimal growth during pregnancy will have a greater chance of reaching its full potential in terms of intelligence, academic achievement, and productivity in adulthood. Meeting adequate nutritional needs during pregnancy is a long-term investment in maternal and child health. Adequate nutrition does not only support the physical growth of the fetus, but also the development of important body parts such as the heart, brain, and lungs. Moreover, good nutrition helps prevent pregnancy complications such as anemia, preeclampsia, and gestational diabetes which are risky for both the mother and the baby. The nutritional needs in each trimester can be different and this does not only depend on the amount of food consumed but also the quality of the nutrition intake. Consuming balanced amounts and types of nutrients such as complex carbohydrates, protein, fat, minerals, and vitamins is important to support optimal fetal growth and development[1,2].

Mid-upper arm circumference (MUAC) is an indicator of maternal nutritional status, especially during pregnancy. MUAC can provide an accurate picture of the mother's body fat reserves, which are closely related to long-term nutritional status. If a pregnant woman's MUAC is lower than 23.5 cm, this indicates a high risk of chronic energy deficiency (CED). Pregnant women with CED are considered at high risk because it can interfere with various physiological processes that are closely

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related to the development and growth of the fetus. One of the significant impacts of CED is disruption to the growth and function of the placenta. The placenta, which functions as a link between the mother and the fetus, will experience poor structural changes such as weight and size that are not in accordance with the gestational age. A small and underdeveloped placenta will have difficulty transferring nutrients, oxygen, and hormones from the mother to the fetus. Besides, CED can also cause a decrease in blood volume in pregnant women. This makes the heart work harder when pumping blood to all parts of the body, including the placenta. Consequently, the blood supply to the placenta is not optimal, so that fetal growth is hampered. Lack of nutrient and oxygen supply due to poor placenta function can have an impact on fetal growth and development. Babies born to mothers with CED often have low birth weight, short body length, and small head circumference. This condition will increase the risk of health complications in babies, such as difficulty breathing, hypothermia, and infection[3,4].

The 2018 Basic Health Research data show that the percentage of pregnant women with CED is quite high in Indonesia, namely 17.3%. This indicates an insignificant decrease because, in 2023, it still reached 16.9%. The proportion of low-birth-weight (LBW) babies in Indonesia in 2018 was 6.2%. This figure shows that the Medium-Term Development Plan (RPJM) target has been achieved, which is 8%. In terms of prevalence, it continuously increased with 5.4% of LBW babies in 2007 increasing to 5.7% in 2013, and increasing to 6.2% in 2018. Besides, there was no significant decrease in 2023 because it still reached 6.1%[5–7]. The percentage of pregnant women with CED in West Sumatra increased from 8.84% in 2019 to 9.7% in 2021. This province had a significant increase in this case, namely 16.5% in 2023. The percentage of LBW babies per 1000 live births in West Sumatra is quite high with no significant decrease, namely 22.6% in 2019, 21.1% in 2020, and 21.55% in 2021. The percentage of short-born babies (<48 cm) continuously increase[7–10].

Lack of nutritional intake during pregnancy can significantly affect fetal development and growth, which is reflected in suboptimal anthropometric results of the baby at birth. Low birth weight and birth length are the main indicators of insufficient nutrition during gestation. These parameters reflect overall physical growth and can indicate chronic or acute malnutrition in pregnant women. In addition, head circumference is also an important parameter that can provide information about fetal brain growth. A small head circumference can indicate delayed brain growth that may be caused by a lack of important nutrients such as iron, iodine, and folic acid. Small for gestational age (SGA) babies have a lower birth weight compared to babies of the same age. This condition can be influenced by many factors such as malnutrition, placental disorders, infections, or underlying maternal medical conditions. SGA babies are at risk of various health complications, such as difficulty breathing, hypothermia, hypoglycemia, and an increased risk of neonatal death. Overall, the results of newborn anthropometry can provide a comprehensive picture of the nutritional status of the mother during pregnancy and its impact on fetal growth and development[11,12]

Amalia et al (2020) revealed a significant relationship between the upper arm circumference of pregnant women with newborns' body length and head circumference[13]. Besides, Rani et al (2017) obtained a p-value<0.05 indicating that pregnant women's MUAC can affect birth weight and birth length[14]. Another study by Vasundhara et al (2020) showed that pregnant women's MUAC is related to the incidence of low birth weight (LBW) and small for gestational age (SGA). SGA measurements are carried out as a substitute for identifying newborns with IUGR (intrauterine growth restriction)[15]. This study aims to identify the relationship between MUAC during pregnancy and anthropometry of newborns in West Sumatra. This study is expected to provide a strong scientific basis for designing specific nutritional interventions for pregnant women in this region in order to prevent the high prevalence of LBW, SGA and other complications that can threaten both maternal and baby's health that can be detrimental to them.

METHODS

This quantitative study used a cohort study method using secondary data from a previous study called, the vitamin D Pregnant Woman study (VDPM study). The VDPM study was conducted in West Sumatra in 2018 and the secondary data was reanalyzed from April to July 2024. The study was carried out at Puskesmas, Maternity Clinics, and Hospitals in five regions, namely Padang City, Pariaman City, Padang Pariaman District, Lima Puluh Kota District, and Payakumbuh City. The selection of locations considered the locations in coastal and mountainous areas as well as urban and rural areas. The purpose of this selection is to cover all subject groups based on the characteristics of the West Sumatra Province area[16].

The VDPM study used some instruments such as a questionnaire consisting informed consent, socio-demographic questionnaire (residence, geographic status, pregnancy season, maternal education, maternal occupation, and monthly income), pregnancy profile questionnaire (maternal age, prematurity, history of miscarriage, parity, ANC visits, infant sex, and birth age); MUAC measurement questionnaire, and anthropometry measurement questionnaire for infants (birth length, head circumference, and SGA). Other instruments were maternal and infant anthropometric measurements tools such as digital scales, microtoise, MUAC tapes, infant scales, and infant body length boards[16]. This study involved subjects who met the inclusion and exclusion criteria. The inclusion criteria were 1) Pregnant women who undergo examination at the Puskesmas where the study was conducted; 2) Data on pregnant women recorded in the first trimester 1 (<13 weeks); 3) Data on pregnant women taken in the third trimester (>27 weeks); 4) Declared healthy based on a doctor's examination; 5) Willing to participate in the study until completion by signing the informed consent and complying with the research procedures; 6) Data on pregnant women with *aterm* birth or ideal and mature gestational age lasting between 37-40 weeks; 7)

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Complete dataset on secondary data from the VDPM Study. Meanwhile, the exclusion criteria are twin births, miscarriages, and stillbirths. The variables studied were the MUAC status of pregnant women in each trimester (1, 2, and 3) and the anthropometry of newborns (Birth Weight, Birth Length, Head Circumference, and SGA).

The data collection process for further data analysis is presented in Figure 1. This study used secondary data obtained from documentation studies. In this study, the researcher analyzed 184 pairs of mothers and babies with a sample calculation technique using the Lemeshow formula. The MUAC variable uses a ratio and ordinal scale with the CED categories (<23.5 cm), normal (23.5-24.9 cm), and more (≥25 cm). The Birth Weight, Birth Length, Head Circumference variables use a ratio and ordinal scale with the LBW categories (<2500 g), normal (2500-3999 g), macrosomia (≥4000 g); Short (<48 cm), normal (48-52 cm), tall (>52 cm); small (<34 cm), normal (34-35 cm), and large (>35 cm). Birth anthropometry of the baby is adjusted to its gestational age based on the Lubencho curve using an ordinal scale with SGA and AGA (Appropriate for gestational age) categories[17–19].

Data analysis used SPSS version 23. Numerical data were presented in the form of median and Interquartile Ratio (IQR) because the data were not normally distributed. Categorical data were presented in frequency (n) and percentage (%). The study used univariate and bivariate testing with Spearman and Wilcoxon Correlation tests. If the p-value<0.05, it is considered significant. The strength of the relationship between the variables is determined by the Rank Correlation Coefficient (R) value. Univariate analysis was carried out to describe the data distribution by understanding the basic characteristics of the data. The univariate analysis covered characteristic data, pregnancy profile, MUAC of pregnant women, and infant anthropometry. Bivariate analysis was carried out to test the hypothesis and measure the strength of the relationship between variables. The bivariate analysis covered the MUAC status of pregnant women and the anthropometry of newborns[20]. This study considers the security and privacy of respondent data and has obtained ethical approval from the Ethics Commission of Alma Ata University on 9 July 2024 with letter number KE/AA/VII/10111877/EC/2024.

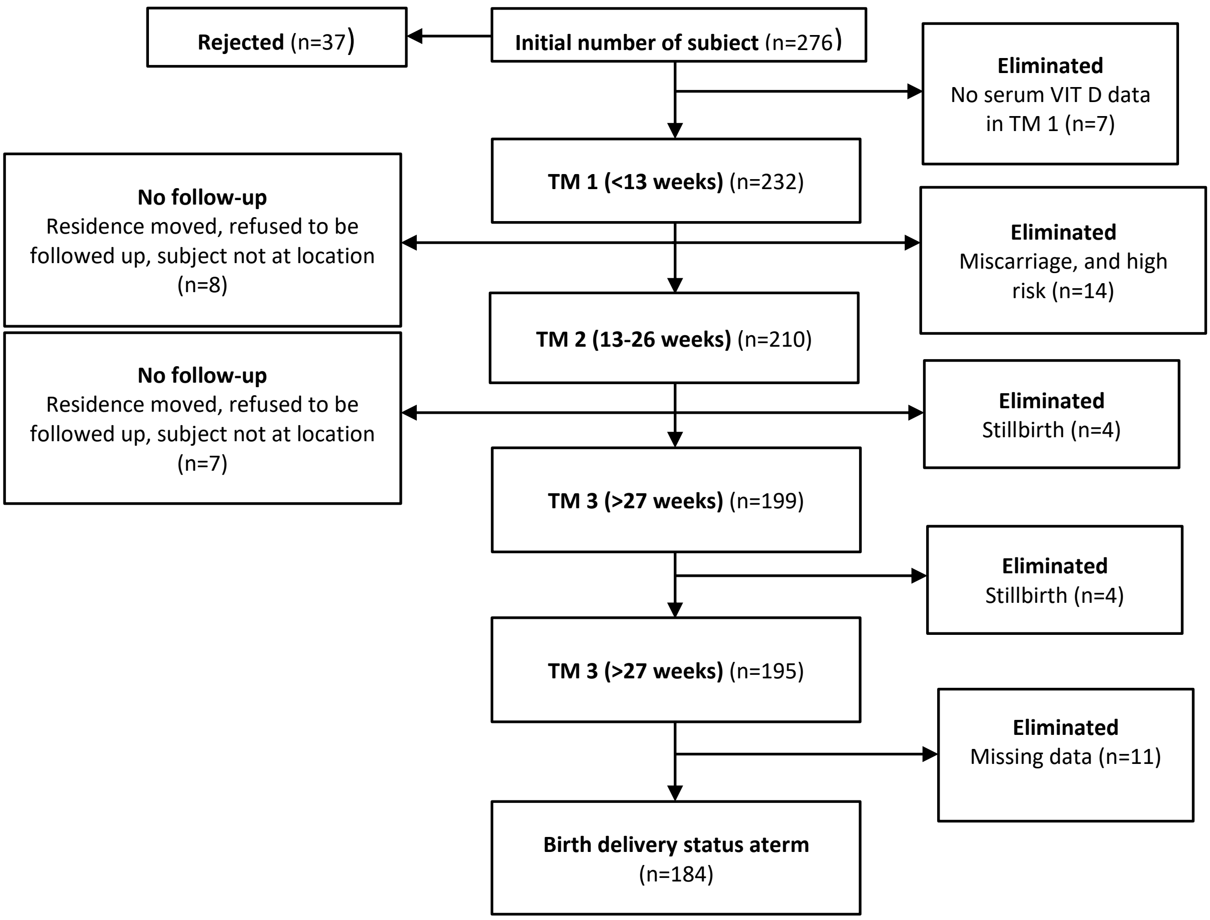

Figure 1. Flow of Research Subject in the VDPM Cohort Study

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RESULTS AND DISCUSSIONS

Characteristics of Respondents

Table 1 shows that the location of residence and demographic status of pregnant women are evenly distributed. Based on social status, most pregnant women have junior high school/high school education levels, namely 40.2%; do not work (69%); and most have incomes above the minimum wage (72.8%). The table also explains that most mothers (52.2%) are in the non-risk range (>20-30 years) with a median of 29 years (IQR=25-33); have given birth once (76.1%); have Antenatal Care (ANC) visits>6 times (65.3%); never had a miscarriage (87.5%); gave birth to non-premature babies (96.2%); gave birth to male babies (55.4%); and gave birth to full-term babies (98%) with a median of 39 weeks (IQR=38-40).

High income levels affect the type of food in terms of quality and quantity with a better fulfillment of nutritional status. Low family income will result in a lack of fulfillment of food needs so it will have an impact on the health of pregnant women. Family income affects the family's purchasing power to choose their daily food ingredients. Family income is considered low if the monthly income is not sufficient for the minimum wage standard in the local area. Families with low incomes tend to be less able to meet food needs so they cannot meet nutritional needs properly[21].

Education can be a determinant of a person's socioeconomic status. The high or low status of education is related to access to work and income levels. Educational status also affects a person's ability to receive nutritional information than those with a lower education level. The higher the level of education, the easier to receive and apply nutritional knowledge. A person's education affects their knowledge. It means that if a person has more knowledge related to nutrition, it will be easier to monitor the nutritional status and can carry out nutritional interventions independently. Knowledge related to nutrition actually provides guidance on nutritional intake and the relationship between food and health[22–24].

The best age range for women to get pregnant and give birth is 20-30 years. Thus, women in the younger or older age range are at risk of pregnancy and childbirth. Pregnant women aged 20 years or younger do not have adequate blood circulation from the cervix to the uterus. This can disrupt the process of distributing nutrients from the mother to the fetus. Pregnant women aged 30 years or older are at risk of complications because they have experienced a decline in reproductive function. The age of the pregnant woman also has a psychological impact on readiness for pregnancy, one of which affects knowledge of having ANC visits. Risky pregnancy, not having regular ANC visits, and not paying attention to nutritional status can cause prematurity. Prematurity is a baby born<37 weeks or weighing less than 2500 g. Prematurity is at risk of disrupting the baby's development because the baby's organ growth is not yet perfect[21,25].

Factors influencing LBW are premature birth and maternal pregnancy profile such as parity, age, history of miscarriage, and pregnancy spacing. Parity is the number of pregnancies that the mother has experienced. Parity 2-4 is the safest for mothers to get pregnant in terms of the prevalence of maternal death, while poor parity has a high risk of maternal death. Mothers with high parity are at risk of experiencing pregnancy complications such as pre-eclampsia and placental imperfections that can interfere with fetal growth and development. Pregnancy spacing of less than 2 years increases the incidence of LBW because the reproductive organs are not yet fully ready causing poor nutritional intake and affecting fetal growth and development[26–28].

Table 1. Sociodemographic Data and Pregnancy Profile (N=184)

Variable	Frequency (n)	Percentage (%)
Research Location		
Padang	9	4.9
Padang Pariaman	31	16.8
Payakumbuh	46	25.0
Limapuluh Kota	63	34.2
Pariaman	35	19.0
Geographic Status		
Coastal Area	75	40.8
Mountainous Area	109	59.2
Residential Status		
Urban	90	48.9
Rural	94	51.1
Maternal Education Level		
Low	50	27.2
Moderate	74	40.2
High	60	32.6
Monthly Income (million)		
Lower than UMR (<2.2)	50	27.2
Higher than UMR (≥2.2)	134	72.8
Monthly Income Status		

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Variable	Frequency (n)	Percentage (%)
Unemployed	127	69.0
Employed	57	31.0
Maternal Age (year) [Median (IQR)]	29 (25-33)	
<20	6	3.3
21-25	45	24.5
26-30	51	27.7
>30	82	44.5
Parity Status		
Nulliparous	44	23.9
Primiparous	140	76.1
Premature Birth Status		
Premature	7	3.8
Normal	177	96.2
Miscarriage status		
Yes	23	12.5
No	161	87.5
ANC Visit		
<6 times	64	34.7
≥6 times	120	65.3
Baby's Sex		
Male	102	55.4
Female	82	44.6
Age of Birth (week) [Median (IQR)]	39 (38-40)	
Term (≥36)	180	2.0
Pre-Term (<36)	4	98.0

Descriptive test of sociodemographic data and pregnancy profile. Low Education Level (Not attending School/Elementary School (SD)), Moderate (Junior High School (SMP)/Senior High School (SMA)), High (D3/Bachelor), Regional Minimum Wage (UMR), *Nulliparous* Parity (No Pregnancy History), *Primiparous* Parity (Pregnancy History), Antenatal Care (ANC), Interquartile Ratio (IQR)

Data Characteristics of Pregnant Women's MUAC and Anthropometry of Newborns

MUAC measurements were performed three times during pregnancy in each trimester. Table 2 shows that most pregnant women were overweight, namely 59.8% in the first trimester with a median of 26 cm (IQR=24-29), 58.7% in the second trimester with a median of 26 cm (IQR=24-29), and 70.1% in the third trimester with a median of 27 cm (IQR=25-30). Newborn anthropometric data show that the median birth weight of babies is 3200 g (IQR=3000-3500) with a normal birth weight category of 88%. The median birth length is 49 cm (IQR=48-50) with a normal birth length category of 82.6%. The median birth head circumference is 34 cm (IQR=33-35) with a category of a normal head circumference of 51.6%. Weight appropriate for gestational age reaches 94%, while body length and head circumference appropriate for gestational age reach 92.4% and 95.1% respectively.

Maternal health parameters can be seen from their nutritional status by measuring the mid-upper arm circumference (MUAC). MUAC≥23.5 cm means that the nutritional status is normal and MUAC<23.5 cm means that the nutritional status is lacking. The relationship between MUAC and birth anthropometry is that MUAC describes long-term eating habits. This chronic energy deficiency causes pregnant women to not have enough nutritional reserves to meet the physiological needs of their pregnancy. Changes in increasing blood volume and hormones for fetal growth increase the need for nutrient supply. Inadequate nutritional status can inhibit the growth and development of the baby in the womb and risk of low birth weight and short[29–32].

Maternal nutrition plays a major influence on the fetus. Chronic energy deficiency (CED) in pregnant women can result in complications in the mother and fetus. CED can cause various problems during childbirth such as prolonged labor, premature, and preeclampsia. Besides, CED also has a negative impact on fetal development. Pregnant women suffering from CED can be at risk of miscarriage, stillbirth, birth defects, anemia in babies, asphyxia, and LBW babies. The CED can be identified from MUAC measurement status at the first ANC visit. Knowing the MUAC status aims for early detection and can be a reference to prevent CED. Pregnant women suffering from CED have a risk of giving birth to LBW babies[3,33].

Head circumference is the standard for examining pathological conditions of head size and procedures for measuring the increase in head size. Measuring the head circumference of newborns is important to determine the development of the baby's nerves and brain development during pregnancy. The MUAC of pregnant women supports the size of the head circumference of newborns, so maternal nutritional status during pregnancy has an impact on the growth of fetal nerve

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cells. Brain growth and development during pregnancy are influenced by the availability of nutrients during pregnancy. Lack of macronutrients, vitamins, and minerals in pregnant women will result in less optimal brain cell growth leading to a reduction in brain size and dysfunction[29,34].

Table 2. Data on Characteristics of Pregnant Women's MUAC and Newborn Anthropometry (N=184)

Variable	Frequency (n)	Percentage (%)
MUAC Status in TM 1 (cm) [Median (IQR)]	26 (24-29)	
CED	27	14.7
Normal	47	25.5
Overweight	110	59.8
MUAC Status in TM 2 (cm) [Median (IQR)]	26 (24-29)	
CED	28	15.2
Normal	48	26.1
Overweight	108	58.7
MUAC Status in TM 3 (cm) [Median (IQR)]	27 (25-30)	
CED	18	9.8
Normal	37	20.1
Overweight	129	70.1
Birth Weight Status (g) [Median (IQR)]	3200 (3000-3500)	
Low (<2500 g)	12	6.5
Normal (2500-3999 g)	152	88.0
Macrosomia (≥4000 g)	10	5.4
Birth Length Status (g) [Median (IQR)]	49 (48-50)	
Short (<48 cm)	32	12.4
Normal (48-52 cm)	152	82.6
Head Circumference Status (cm) [Median (IQR)]	34 (33-35)	
Small (<34cm)	56	30.4
Normal (34-35 cm)	95	51.6
Big (>35 cm)	33	17.9
SGA-BB Status		
AGA	173	94.0
SGA	11	6.0
SGA-PB Status		
AGA	170	92.4
SGA	14	76.0
SGA-LK Status		
AGA	175	95.1
SGA	9	4.9

Descriptive test of data characteristics of MUAC and anthropometry of newborns. MUAC categories cover underweight/CED (<23.5 cm); Normal (≥23.5-25 cm); and Overweight (>25 cm). Trimester (TM); Small for Gestational Age-Body Weight (SGA-BB), Small for Gestational Age-Body Length (SGA-PB), Small for Gestational Age-Head Circumference (SGA-LK), Appropriate for Gestational Age (AGA), Chronic energy deficiency (CED), Small for Gestational Age (SGA), Interquartile Ratio (IQR)

Relationship between MUAC of Pregnant Women and Anthropometry of Newborns

Table 3 shows that MUAC status has a relationship with the birth weight of the baby (p-value<0.05). The correlation results show a positive value although it has a weak relationship. The MUAC status has a significant relationship with the birth length of the baby has a significant relationship (p-value<0.05) with a very weak correlation level in the first and second trimesters and a weak correlation level in the third trimester. Moreover, MUAC has a significant relationship with head circumference (p-value<0.05) with a weak positive correlation in the third trimester and a very weak correlation in the first and second trimesters. This means that the larger the size of the MUAC of the pregnant women, the larger the anthropometric size of the baby, although it has a weak Spearman Correlation value.

The results of the Spearman Correlation test showed a weak correlation between the MUAC status of pregnant women and the anthropometry of newborns. MUAC is an indirect factor affecting the anthropometry of newborns. MUAC can measure the percentage of body fat in pregnant women where the fat mass describes the nutritional status of the mother during pregnancy. Increased fat tissue can directly affect the increase in fat and glucose concentrations in blood circulation. This affects growth, weight, and surface area and increases the transport capacity of the placenta. The heavier and wider the size of the placenta, the more optimal the capacity of nutrient transport to the fetus. On the other

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hand, pregnant women suffering from CED will experience glucose, amino acid, and fat deficiencies that are needed during placental formation and fetal growth. Imperfect placental size will result in decreased transfer of nutrients and oxygen and inhibition of fetal growth and development. Unfulfilled fetal nutritional needs during pregnancy can result in poor birth anthropometry such as LBW, short, small head circumference, and SGA[30,31].

Excessive body fat percentage does not guarantee good anthropometry of the baby but can be associated with obesity status. Obesity is a risk factor for preeclampsia with marker symptoms of high blood pressure. Hypertension sufferers during pregnancy experience failure of spiral artery restructuring resulting in placental ischemia. The placenta experiencing ischemia can produce oxidants. Hypertension in pregnancy causes high levels of oxidants, especially increased fat peroxides, while antioxidants, for example vitamin E in pregnancy are low so that there is a dominance of increased levels of fat peroxide oxidants. Fat peroxides as toxic oxidants or free radicals will flow in the bloodstream and damage the endothelial cell membrane. This causes narrowing of the placental blood vessels, reducing blood flow and nutrition to the fetus. Consequently, fetal growth is inhibited. Increased lipid peroxides cause a decrease in antioxidants such as vitamin E. Preeclampsia increases the production of free radicals which can damage fetal cells and inhibit growth. The inflammatory process that occurs in preeclampsia can also interfere with fetal growth and cause pre-term birth[17].

This study is in line with Yuliana and Istianah (2021) that pregnant women with MUAC<23.5 cm or CED are 6 times more at risk of giving birth to LBW babies with a p-value of 0.002 and OR value of 6.2335. Ningrum and Cahyaningrum (2018) also revealed the significance between nutritional status and birth weight of the baby with a p-value of 0.01 (r=0.390)[36]. Another study by Amalia et al (2020) showed that MUAC had a significant relationship with LKL with a p-value of<0.001[13].

Table 3. Correlation Analysis of MUAC of Pregnant Women with Newborn Anthropometrics (N=184)

Anthropometric of Newborns	MUAC TM 1		MUAC TM 2		MUAC TM 3	
	p-value	R	p-value	R	p-value	R
Birth Weight	0.002*	0.23	0.002*	0.22	≤0.001*	0.27
Birth Length	0.009*	0.19	0.011*	0.19	0.002*	0.23
Head Circumference	0.029*	0.16	0.024*	0.17	0.003*	0.21

Correlation of MUAC status with newborn anthropometry using Spearman Correlation Test. *) If the p-value<0.05, it indicates a relationship. Rank Correlation Coefficient (R) categories include very weak (0.009-0.199), weak (0.20-0.399), sufficient (0.40-0.599), strong (0.60-0.799), and very strong (0.80-0.100). p-value (Significance), shows a relationship if p-value<0.05, MUAC; Ratio (R); Trimester (TM)

The Relationship between MUA Status and SGA

Table 4 shows that AGA babies come from mothers with MUAC≥23.5 cm. Based on the median distribution, all CED mothers give birth to SGA babies. The Wilcoxon test obtained a p-value of 0.01 which is lower than 0.05. This indicates a significant relationship between MUAC and SGA. Pregnant women with CED (MUAC<23.5 cm) are at risk of experiencing pregnancy complications including anemia. Pregnant women with CED do not have sufficient energy reserves for their pregnancy so they do not have enough iron and vitamin B12. CED can cause anemia because they cannot produce sufficient red blood cells. Anemia in pregnant women occurs because the need for oxygen is higher so that the volume of blood plasma and erythrocytes increases. Increased production of plasma volume followed by decreased hemoglobin can cause anemia. Pregnant women with anemia are at risk of premature labor and giving birth to LBW babies. Low maternal red blood cells are also often associated with LBW and SGA as decreased hemoglobin concentration can affect the baby's birth weight[37].

SGA refers to babies who are born smaller than expected for their gestational age. SGA babies often have stunted growth in the womb. The relationship between MUAC and SGA is very close, pregnant women with small MUAC (less than 23.5 cm) have a higher risk of giving birth to SGA babies. Mothers with low MUAC tend to lack nutrients such as protein, vitamins, and minerals needed for fetal growth. Low energy reserves in pregnant women with low MUAC can inhibit optimal fetal growth. Low MUAC is often associated with poor maternal health conditions such as anemia or infection, which can also affect fetal growth. SGA is another predictor to identify LBW. SGA can be determined by comparing the birth weight of the baby with the fetal growth standard in the gestational week. Babies with a birth weight less than the 10th percentile of the standard population according to their birth week are considered SGA. CED in pregnant women is considered a strong contributor to the incidence of SGA. Small birth occurs in fetuses who experience prolonged malnutrition during pregnancy. This changes the physical characteristics of the baby and causes SGA or physical size that is not in accordance with gestational[38–40].

These results are in line with Vasundhara et al (2020) that pregnant women with low MUAC status (CED) are at higher risk of giving birth to SGA babies compared to those with normal MUAC status[15]. This is also in line with Ambreen et al (2024) that 34.4% of women with MUAC<23.5 cm gave birth to SGA babies. Pregnant women suffering from CED had a 1.64 (OR=1.64 95% CI) times greater risk of giving birth to SGA babies than those with normal MUAC status[39]. Moreover, Annigeri et al (2022) revealed that MUAC can be used to predict SGA with a sensitivity of 85.4% and a specificity of 72.1%. In this study, bivariate analysis obtained a p-value of<0.001 (<0.05) indicating that MUAC status had a significant relationship with SGA[41].

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Table 4. Analysis of the Relationship between MUAC Status of Pregnant Women and SGA (N=184)

MUAC (cm)		SGA-BB		SGA-PB		SGA-LK	
		AGA	SGA	AGA	SGA	AGA	SGA
TM 1	Median (IQR)	26 (24-29)	25 (23-28)	26 (24-29)	25 (23-28)	26 (24-30)	24 (22-28)
	p-value	≤0.001*		≤0.001*		≤0.001*	
TM 2	Median (IQR)	26 (24-30)	25 (23-28)	26 (24-30)	25 (24-28)	26 (24-30)	25 (22-28)
	p-value	≤0.001*		≤0.001*		≤0.001*	
TM 3	Median (IQR)	27 (25-31)	25 (22-29)	27 (25-30)	26 (24-31)	27 (25-30)	25 (23-28)
	p-value	≤0.001*		≤0.001*		≤0.001*	

Bivariate analysis using Wilcoxon. *) There is a relationship if p-value<0.05. Mid-Upper Arm Circumference (MUAC); Interquartile Ratio (IQR); Small for Gestational Age-Body Weight (SGA-BB), Small for Gestational Age-Body Length (SGA-PB), Small for Gestational Age-Head Circumference (SGA-LK), Appropriate for Gestational Age (AGA), Trimester (TM)

This study explains the relationship between the MUAC status of pregnant women and complete newborn anthropometry such as birth weight, birth length, head circumference, and SGA. This study explains the relationship and reveals the influence of MUAC status on newborn anthropometry based on the correlation coefficient value. This study has some limitations such as not examining more deeply the nutritional intake or other characteristics that can affect MUAC and newborn anthropometry. Future studies are expected to further examine the relationship between MUAC and newborn anthropometry.

CONCLUSIONS

MUAC status of pregnant women and the anthropometry of newborns have a significant positive correlation. The greater the MUAC, the greater the anthropometry of the baby born, but the correlation value status is relatively weak. There is also a significant correlation between the MUAC status of pregnant women and SGA status. Babies with AGA status come from mothers with normal MUAC status and mothers suffering from CED tend to give birth to babies with SGA status. Future studies are expected to confirm these findings with a wider sample and examine characteristic factors that support and influence the relationship between the MUAC status of pregnant women and the anthropometry of newborns. Specific intervention testing can be carried out to understand the long-term impact of maternal nutritional status.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

AM: analysis and interpretation of research data, writing research manuscript, revising the editorial; ASA: conceptualization, research design, writing initial manuscript, reviewing the manuscript, writing revision; WI: supervising the manuscript, reviewing the manuscript, revising the editorial; EF: supervising the manuscript, reviewing the manuscript, revising the editorial; NIL: conceptualization and research design. All authors have approved the final version of the manuscript.

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