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The correlation between Body Mass Index (BMI) and Mid Upper Arm Circumference (MUAC) of mothers with low birth weight in Malang city in 2021-2023

Azwan Yusuf Maulana [1,*], Dewi Ratna Sari [2], Sri Ratna Dwiningsih [3] and Atika [4]

[1] *Medical Program, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*
[2] *Department of Anatomy, Histology, and Pharmacology, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*
[3] *Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*
[4] *Department of Public Health and Preventive Medicine, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*

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Abstract

Background: Low Birth Weight (LBW) is the leading cause of neonatal death in East Java, accounting for 34.5% of cases in 2021. In Malang City, LBW cases increased from 348 (2021) to 501 (2023). LBW infants are at higher risk for respiratory distress, hypoglycemia, neurological disorders, and infections. Early assessment of maternal Body Mass Index (BMI) and Mid-Upper Arm Circumference (MUAC) may help prevent LBW. Research on the relationship between BMI, MUAC, and LBW in Malang City has not been conducted previously.

Objective: To analyze the relationship between maternal BMI and MUAC with LBW at Adjoining and Contumely Health Centers, Malang City, from 2021–2023.

Methods: This retrospective correlational study used a quantitative approach, with ethical approval (No. 124/EC/KEPK/FKUA/2024). A sample of 128 mothers delivered live singleton LBW infants was selected through purposive sampling. Data on BMI and MUAC were obtained from medical records during the last antenatal care visit. Analysis was performed using the Spearman correlation test at a 95% significance level with Microsoft Excel and SPSS.

Results: A very weak positive correlation was found between maternal BMI and LBW (p=0.043; rs=0,179). No correlation was observed between MUAC and LBW (p=0.073). Moderate and weak positive correlations were found for BMI (p=0.005; Rs=0.460) and MUAC (p=0.019; Rs=0.394) in the first trimester.

Conclusion: Maternal BMI shows a very weak positive correlation with LBW, moderate in the first trimester, while maternal MUAC in the first trimester has a weak positive correlation with LBW.

Keywords: Body Mass Index; Mid-Upper Arm Circumference; Low Birth Weight; Nutrition Status; Anthropometry

1. Introduction

Low Birth Weight (LBW) infants are defined as neonates born weighing less than 2,500 grams [1]. According to WHO [2] estimates, 60–80% of neonatal mortality is attributed to LBW, particularly within the first four weeks of life. LBW infants face a forty-fold higher risk of perinatal death compared to normal birth weight neonates [3]. Low Birth Weight remains the leading cause of neonatal mortality as of 2021, accounting for 34.5% of cases. East Java Province reported an LBW incidence rate 1.3% higher than the national average across Indonesian provinces. In 2021, 18,739 LBW cases were recorded in East Java, contributing to 993 neonatal deaths (aged 0–28 days) [4].

* Corresponding author: Azwan Yusuf Maulana

Infants born with Low Birth Weight (LBW) exhibit slower growth and developmental rates compared to those with normal birth weight. This condition is further exacerbated by inadequate nutrient intake, suboptimal caregiving practices, and frequent infectious diseases, leading to a higher prevalence of poor or deficient nutritional status among LBW infants [5]. Preventive measures against LBW are essential to mitigate the risks of neonatal mortality and associated comorbidities.

One of the primary factors contributing to Low Birth Weight (LBW) is maternal nutritional status [6]. Maternal nutrition before conception and during pregnancy plays a critical role in fetal growth and development. The first 1,000 days of life (spanning from conception to two years postnatally) underscore the importance of optimal maternal nutrition in determining early infant development and the risk of nutrition-related chronic diseases in adulthood [6]. Several methods exist to assess maternal nutritional status in pregnancy, but the two most commonly utilized are Body Mass Index (BMI) and Mid-Upper Arm Circumference (MUAC). These methods are recognized for their simplicity, cost-effectiveness, and ease of application in evaluating maternal nutritional status [7].

Body Mass Index (BMI) is a measurement that compares weight to height and can be used to estimate the nutritional status of pregnant women [8]. Body weight reflects the total amount of protein, fat, water, and minerals in the body. Weight changes can be observed over short periods and may indicate current maternal nutritional status. Mothers with low pre-pregnancy weight or inadequate gestational weight gain are more likely to deliver Low Birth Weight (LBW) infants [9].

Mid-upper arm circumference (MUAC) reflects the growth of adipose and muscle tissue unaffected by body fluid fluctuations, making it a reliable indicator of nutritional status in women of reproductive age (WRA) or pregnant women. MUAC serves as an inexpensive, simple, and portable assessment tool that can be self-administered. Its color-coded design enables utilization even by illiterate populations for nutritional status classification [9].

Based on the aforementioned theories, both Body Mass Index (BMI) and Mid-Upper Arm Circumference (MUAC) serve as significant predictive indicators for Low Birth Weight (LBW) outcomes. While numerous studies have investigated this relationship, no current research has examined the association between BMI/MUAC and LBW in Malang City during 2021-2023. According to the 2021 Malang City Health Profile report, Kedungkandang and Sukun districts demonstrated the highest LBW incidence rates. This study aims to investigate the correlation between maternal BMI and MUAC with LBW incidence in these two high-prevalence districts of Malang City.

2. Material and methods

2.1. Study Design

This research is a correlative study with a retrospective research design and quantitative approach, to assess the relationship between BMI and MUAC of pregnant women with LBW babies.

2.2. Data Source and Patient Selection

This research uses secondary data from medical records of pregnant women at the Arjowinangun and Ciptomulyo Health Centers, Malang City, Indonesia, 2021-2023.

The population in this study were all mothers giving birth at the Arjowinangun and Ciptomulyo Health Centers, Malang City. The sample was selected by using purposive sampling technique in determining the respondents. The total number of respondents was 128 people.

2.3. Sample Size Calculation

The minimum sample size was calculated using Cohen's correlation formula [10]:

$$n = \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{0{,}5 \times \ln\left(\frac{1+r}{1-r}\right)} \right)^2 + 3$$

n = minimum required sample size

Z_(1-α/2) = 1.96 (95% significance level, α=0.05)

Z_(1-β) = 1.28 (90% statistical power, β=0.10)

r = 0.3 (minimum clinically meaningful correlation coefficient)

$$n = \left(\frac{1{,}96 + 1{,}28}{0{,}5 \times \ln\left(\frac{1 + 0{,}3}{1 - 0{,}3}\right)} \right)^2 + 3$$

The calculation yielded a minimum sample size of 113 participants to achieve 95% confidence level and 90% statistical power for detecting clinically relevant correlations (r≥0.3).

2.4. Inclusion and Exclusion Criteria

The following criteria were used to determine the eligibility of patient records for inclusion in this study:

2.4.1. Inclusion Criteria

- This study included mothers who delivered live singleton Low Birth Weight (LBW) infants at Arjowinangun and Ciptomulyo Community Health Centers in Malang City between January 2021 and July 2023.

2.4.2. Exclusion Criteria

- Multiple gestations (twins or higher-order multiples)
- Cases with incomplete medical documentation

2.5. Data Collection

This retrospective study analyzed medical records of pregnant women who delivered at Arjowinangun and Ciptomulyo Community Health Centers in Malang City during 2021-2023. The study examined the following variables:

2.6. Independent Variable

- Maternal Body Mass Index (BMI) - Calculated as weight (kg)/height^2 (m^2)
- Mid-Upper Arm Circumference (MUAC) - Measured at the midpoint between acromion and olecranon (cm)

2.6.1. Dependent Variable

- Neonatal birth weight - Recorded immediately after delivery (grams)

2.7. Data Analysis and Presentation

2.7.1. Normality Testing

The Kolmogorov-Smirnov test was employed to assess data distribution, with statistical significance set at α=0.05 (95% confidence level).

2.7.2. Analytical Software

Data processing was performed using:

- Microsoft Excel 2021 for data management
- IBM SPSS Statistics 27 for statistical analyses

2.7.3. Analytical Methods

Univariate Analysis

- Calculated frequency distributions and descriptive statistics for all variables

Bivariate Analysis

- Spearman's rank correlation test was conducted to examine:
  - Relationship between maternal BMI and LBW

  - Association between MUAC and LBW
- Statistical significance threshold: $p<0.05$

3. Results and discussion

3.1. Respondent Characteristics

Table 1 Profile of Pregnant Women Attending Arjowinangun and Ciptomulyo Primary Health Centers, Malang City, 2021–2023

No	Characteristics	Mean ±SD	Frequency (N)	Percentage (%)
1	Maternal Age	29.67 ± 6.40	128	
	<20 years		7	5.47%
	20-35 years		91	71.09%
	>35 years		30	23.44%
2	Gestational Age	37.16 ± 2.47	128	
	<37 weeks		55	42.97%
	37-40 weeks		60	46.88%
	>40 weeks		13	10.15%
3	Maternal Body Weight	57.05 ± 12.67	128	
4	Maternal Height	1.52 ± 0.05	128	
5	Maternal BMI	24.66 ± 5.34	128	
	<18.5 kg/m²		16	12.50%
	18.5-22.9 kg/m²		39	30.47%
	23-24.9 kg/m²		18	14.06%
	25-29.9 kg/m²		32	25.00%
	≥30 kg/m²		23	17.97%
6	Maternal MUAC	26.27 ± 3.97	128	
	<23.5 cm		38	29.69%
	≥23.5 cm		90	70.31%
7	Birth Weight (by Gestational Age)	2295.04 ± 139.10	128	
	<37 weeks	2290.64 ± 131.54	55	42.97%
	37-40 weeks	2300.75 ± 142.00	60	46.88%
	>40 weeks	2287.31 ± 165.71	13	10.15%

Based on Table 1, the mean maternal age was 29.67 years, with the majority falling within the reproductive age range. Among the three maternal age categories, those classified as high-risk for delivering low birth weight (LBW) infants accounted for 37 cases (28.91%). The mean gestational age at delivery was 37.16 weeks, ranging from 30 weeks to 44 weeks and 2 days. Term and post-term pregnancies constituted 73 cases (57.03%). The average maternal body weight was 57.05 kg, and the mean maternal height was 1.52 meters. The mean maternal Body Mass Index (BMI) was 24.66 kg/m^2. Based on the five BMI categories, 16 mothers (12.50%) were underweight, and 73 mothers (57.03%) were categorized as overweight or obese. The mean mid-upper arm circumference (MUAC) was 26.27 cm, with 38 mothers (29.69%) having MUAC below the normal threshold. The mean birth weight of the infants was 2,295.04 grams.

3.2. Analysis of Study Results

Table 2 Spearman's Correlation Analysis Results

	BMI		**MUAC**	
	p	Rs	p	Rs
LBW	0,043*	0,179	0,073	0,159

*All analyses considered results statistically significant at p < 0.05 (two-tailed).

Table 2 demonstrates a very weak positive correlation between maternal Body Mass Index (BMI) and low birth weight (LBW), indicating that lower maternal BMI is associated with lower infant birth weight. In contrast, the correlation analysis between mid-upper arm circumference (MUAC) and LBW did not reveal a statistically significant association.

Table 3 Spearman's Correlation Analysis Results by Trimester

		BMI		**MUAC**	
		p	Rs	p	Rs
Trimester 1 (n = 35)	LBW	0,005*	0,460	0,019*	0,394
Trimester 2 (n = 56)	LBW	0,132	0,204	0,338	0,130
Trimester 3 (n = 37)	LBW	0,604	-0,088	0,704	0,065

*All analyses considered results statistically significant at p < 0.05 (two-tailed).

Table 3 shows a moderate positive correlation in the first trimester between maternal Body Mass Index (BMI) and low birth weight (LBW), indicating that lower maternal BMI is associated with lower infant birth weight. Additionally, the analysis of maternal mid-upper arm circumference (MUAC) and LBW in the first trimester revealed a weak positive correlation, suggesting that lower maternal MUAC is also associated with lower infant birth weight. However, correlation analyses between BMI and MUAC with LBW in the second and third trimesters did not demonstrate any statistically significant associations.

4. Discussions

4.1. Respondent Characteristics

A study conducted at the Arjowinangun and Ciptomulyo Community Health Centers in Malang City found that the majority of mothers who gave birth to low birth weight (LBW) infants were within the reproductive age range (71.09%), with most pregnancies being at term gestation. These findings are consistent with those reported by Damayanti et al. [11], who found that 65.78% of pregnant women delivering LBW infants were within the reproductive age group. In contrast, a study by Marlen Wati et al. [12] demonstrated different results, indicating that 62.50% of mothers who gave birth to LBW infants were at risk due to maternal age (<20 years or >35 years). This discrepancy suggests that maternal age is a critical factor influencing neonatal birth weight. Biological factors, including hormonal fluctuations and the overall health status of the mother during pregnancy, also contribute significantly to fetal development [13]. Adolescent mothers under the age of 20 often have underdeveloped reproductive organs and face higher nutritional demands due to the competition for nutrients between the mother and the growing fetus, potentially leading to suboptimal fetal growth [14]. Early pregnancies are frequently associated with child marriage, a phenomenon still prevalent in Indonesia. In 2022, the average age of marriage among Indonesian women was below 25 years, with a mean age of 20.63 years [15]. Child marriage in Indonesia is largely driven by socio-economic factors, often occurring despite the girls' physical and psychological immaturity [16].

Adolescent pregnancies, particularly among individuals aged 14–19 years, are associated with increased risks of pregnancy and delivery complications, including a 4.1-fold higher likelihood of delivering low birth weight (LBW) infants compared to mothers aged over 20 years [17]. Infants born with LBW to mothers under 20 years old are more prone to congenital anomalies and physical complications, such as epilepsy, intellectual disability, blindness, and hearing loss [18]. Although survival is possible, these infants are also at elevated risk for developmental delays [19]. On the other end of the reproductive age spectrum, women over the age of 35 often experience a physiological decline, particularly in reproductive function. This decline may affect oocyte quality and the uterine environment's capacity to support fetal growth [20]. Additionally, age-related physiological changes can impair nutrient absorption, which may indirectly hinder fetal development [21].

Despite limited field data, statistical records indicate the prevalence of anemia among pregnant women in Malang City from 2021 to 2023. In 2021, 2022, and 2023, the proportions of pregnant women diagnosed with anemia were 23.31%, 13.66%, and 12.27%, respectively [22,23,24]. Anemia leads to a reduction in hemoglobin levels and serves as an indicator of deficiencies in key nutrients, particularly iron and essential vitamins, which in turn impairs the transfer of oxygen and nutrients to the fetus [25]. Inadequate fetal oxygenation and nutrient supply can disrupt fetal growth and result in reduced birth weight [26].

Another significant factor contributing to the incidence of low birth weight (LBW) is gestational age. Gestational age plays a critical role in determining neonatal birth weight. In the present study, the highest proportion of LBW cases (46.88%) occurred among mothers who delivered at term gestation. This finding aligns with the study by Maria and Fitriana [27], which reported that 78.13% of LBW cases were observed in mothers with term pregnancies. The authors hypothesized that maternal age may have influenced these results, as 71.88% of mothers who delivered LBW infants were in the high-risk age categories (<20 years and >35 years) [27]. Similarly, Damayanti et al. [11] reported that 70.15% of 412 respondents experienced LBW births at term gestational age. They suggested that other contributing factors might include low maternal education (91.26%), inadequate antenatal care visits (82.04%), high-risk parity (67.23%), maternal anemia during pregnancy (61.17%), and infections during pregnancy (65.53%) [11]. In contrast, findings from Parini et al. [28] indicated that 62.26% of LBW deliveries occurred in preterm pregnancies (<37 weeks of gestation).

Gestational age refers to the duration of fetal development in the uterus, calculated from the first day of the last menstrual period (LMP) until delivery [29]. During the first trimester, organogenesis occurs, and as gestation progresses, the fetus continues to gain both length and weight. Of the recommended maternal weight gain of 25–35 pounds during pregnancy, approximately 8 pounds are attributed to the fetus and 4 pounds to the amniotic fluid [13]. Preterm birth is defined as delivery occurring between 20 and 37 weeks of gestation. At this stage, the fetus is not yet fully developed, which significantly increases the risk of low birth weight (LBW) [29]. Sholiha [30] further explained that premature infants are at increased risk of LBW due to impaired development of subcutaneous fat storage systems.

4.2. Analysis of the Association Between Maternal Body Mass Index (BMI) and the Incidence of Low Birth Weight (LBW)

Based on this study result, a positive correlation was observed between maternal body mass index (BMI) and neonatal birth weight, although the correlation was weak ($p = 0.043$). These findings are consistent with the study by Riantika et al. [31], which reported a significant association between maternal BMI and the incidence of low birth weight (LBW) ($p = 0.001$). Although the majority of LBW cases occurred in mothers with a normal BMI (63.41%), the risk of delivering an LBW infant was found to be 2.051 times higher among mothers with abnormal BMI values [31].

Liu et al. [32] conducted a systematic review and meta-analysis to investigate the association between maternal body mass index (BMI) and the risk of neonatal adverse outcomes among women in China. A total of 15 studies involving 313,569 participants were included to evaluate the relationship between maternal BMI and low birth weight (LBW). The analysis concluded that underweight status prior to pregnancy (BMI <18.5 kg/m^2) increased the risk of delivering an LBW infant by 1.61 times ($p = 0.022$). This association is explained by the fact that maternal BMI reflects the mother's nutritional status, which is essential for both maternal health and fetal development during pregnancy [33]. Abnormal BMI can disrupt maternal metabolic balance, including blood glucose and insulin levels, thereby affecting fetal growth and neonatal birth weight [34]. Elevated maternal BMI beyond the normal range (i.e., obesity) is strongly associated with an increased risk of preeclampsia, peripheral edema, and macrosomia (birth weight ≥4,000 g), often necessitating cesarean delivery. Conversely, low maternal BMI is closely linked to preterm birth and LBW [35].

Maternal nutritional status during pregnancy can be monitored through gestational weight gain (GWG), defined as the difference between pre-pregnancy weight and the final weight before delivery. GWG is typically categorized as inadequate, adequate, or excessive. The Institute of Medicine (2009) provides GWG recommendations based on pre-pregnancy body mass index (BMI) categories: for underweight women (BMI <18.5 kg/m^2), 12.5–18.0 kg; normal weight (18.5–24.9 kg/m^2), 11.5–16.0 kg; overweight (25.0–29.9 kg/m^2), 7.0–11.5 kg; and obese (≥30 kg/m^2), 5.0–9.0 kg (Institute of Medicine, 2009). Appropriate management of GWG in accordance with these guidelines has been shown to reduce the risk of adverse perinatal outcomes [32,36,37]. Tam and He [38] explain that the physiological basis of GWG includes contributions from fetal weight, maternal fat accumulation, and fluid retention. At term, the average maternal weight gain is composed of the fetus (3.2–3.6 kg), maternal fat stores (2.7–3.6 kg), increased blood volume (1.4–1.8 kg), extravascular fluid (0.9–1.4 kg), amniotic fluid (0.9 kg), breast tissue enlargement (0.45–1.4 kg), uterine growth (0.9 kg), and placenta (0.5–0.7 kg) [38].

Several studies have demonstrated a significant association between pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) with the incidence of low birth weight (LBW). Murai et al. [39] investigated 1,336 respondents who delivered at the Japanese Red Cross Medical Center in the Tokyo metropolitan area. Among them, 62.50% of mothers with a normal pre-pregnancy BMI experienced LBW outcomes (p = 0.035). Although a greater proportion of LBW cases occurred in women with normal BMI, those with inadequate GWG (<8.5 kg) had the highest frequency (46.43%) of LBW deliveries (p = 0.027). Similarly, a study by Ciptaningtyas et al. [40] reported that 60.78% of mothers with a normal pre-pregnancy BMI had LBW infants, although the association was not statistically significant (p = 0.096). However, 70.59% of mothers with inadequate GWG were found to be 5.318 times more likely to deliver LBW infants (p = 0.000). These findings strongly support the importance of managing GWG to compensate for suboptimal pre-pregnancy BMI, especially in accordance with the IOM recommendations. Further supporting this evidence, Nepal et al. [41] reported a positive association between GWG and neonatal birth weight. After adjusting for confounding factors such as age, education, ethnicity, occupation, parity, and BMI, every 1 kg/week increase in GWG during the second to third trimester was associated with a 392 g increase in birth weight (p = 0.018). Moreover, excessive GWG was associated with an additional 148 g increase in birth weight compared to normal GWG (p = 0.037) [41].

4.3. Analysis of the Association Between Maternal Mid-Upper Arm Circumference (MUAC) and the Incidence of Low Birth Weight (LBW)

In general, measurement of mid-upper arm circumference (MUAC) in early pregnancy is closely associated with neonatal birth weight. However, in the present study, no significant association was found between maternal MUAC and birth weight (p = 0.073). Approximately 70.31% of the total 128 pregnant women had a MUAC ≥23.5 cm, with a mean ± SD of 26.27 ± 3.97 cm. These findings suggest that the majority of participants were in an overweight to obese nutritional status category. This result contrasts with findings from previous studies by Maria and Fibriana [27], Nisa et al. [42], Purnama and Kurniasari [43], Rizqi et al. [44], and Zulfikar [45], all of which reported a significant association between maternal MUAC and the incidence of low birth weight (LBW).

Wijayanti et al. [46] conducted a meta-analysis to evaluate the association between maternal nutritional status—reflected by maternal height, mid-upper arm circumference (MUAC), and nutritional counseling—and the risk of low birth weight (LBW). Eight studies with a combined total of 3,561 participants were included to assess the relationship between maternal MUAC and LBW. The analysis concluded that pregnant women with a MUAC <23 cm had a 3.79-fold increased risk of delivering LBW infants [46]. A similar finding was reported by Adelia and Rohmah [47], who found a significant association between maternal MUAC and LBW (p = 0.025), despite the majority of respondents (70%) having normal MUAC values. The authors suggested that parity may also play a contributing role in LBW incidence. In their study, 78.70% of the participants were primiparous [47]. According to Pinontoan and Tombokan [48], both first parity and grand multiparity (≥4) are associated with increased risk of LBW. First-time pregnancies are at higher risk due to the mother's lack of physiological readiness and inexperience in managing pregnancy [48], while high parity may result in vascular damage to the uterine wall, decreased uterine elasticity from repeated stretching, and maternal nutritional depletion due to physical fatigue [49,35,50]. In contrast, Sary [51] reported a non-significant association between maternal MUAC and LBW (p = 0.302), with most LBW cases occurring among mothers with normal MUAC (≥23.5 cm). This finding highlights an important limitation of MUAC as a nutritional assessment tool: it is not suitable for monitoring short-term changes in maternal nutritional status, thereby requiring supplementary indicators for comprehensive nutritional monitoring during pregnancy [51].

There is ongoing debate regarding the optimal timing for measuring mid-upper arm circumference (MUAC) in pregnant women. According to Amalia [52], MUAC is considered a reliable indicator of maternal nutritional status early in pregnancy, as it remains relatively stable throughout gestation and is minimally affected by edema. In contrast, Vasundhara et al. [53] conducted a study aimed at evaluating whether MUAC could serve as a predictor of low birth weight (LBW) and to determine the optimal MUAC cutoff for such prediction. This study, carried out at a tertiary care government maternity hospital in Hyderabad, Telangana, involved 928 pregnant women whose MUAC was measured at three different time points: 20–26 weeks, 30–34 weeks, and >36 weeks of gestation. The study found that a MUAC cutoff of 23 cm provided the best sensitivity (54.0%) and specificity (59.8%) for predicting LBW. A MUAC measurement of ≤23 cm from 20 weeks of gestation until delivery was identified as a potential predictor of LBW. This finding suggests that MUAC ≤23 cm may serve as a practical screening tool for LBW, particularly in settings where maternal weight assessment is not feasible or antenatal care is delayed, and where prepregnancy weight data are unavailable [53].

Salih et al. [54] also examined the association between mid-upper arm circumference (MUAC) and body mass index (BMI) as indicators of maternal nutritional status during early (<20 weeks) and late (≥20 weeks) pregnancy. A total of 688 pregnant women from New Halfa City, Sudan, were included in the study, which revealed a strong and significant positive correlation between MUAC and BMI. The recommended MUAC cutoffs for identifying underweight status were 24.0 cm in early pregnancy and 23.0 cm in late pregnancy, while the cutoffs for obesity were 29.0 cm and 28.0 cm, respectively. Although BMI is a commonly used anthropometric method to assess nutritional status, it requires calibrated medical scales and stadiometers, as well as trained personnel. MUAC offers a practical alternative for assessing maternal nutritional status, particularly in resource-limited settings [54]. In a related study, Ma et al. [55] found that MUAC could also predict the risk of gestational diabetes mellitus (GDM) in early pregnancy ($p<0.001$). A MUAC measurement >28.5 cm was associated with an 8.851-fold increased risk of GDM, with a sensitivity of 61% and specificity of 77% [55].

Mid-upper arm circumference (MUAC) is an indirect factor that influences neonatal anthropometry. MUAC can be used to estimate the percentage of body fat in pregnant women, where fat mass reflects maternal nutritional status throughout pregnancy. An increase in maternal adipose tissue can directly raise circulating lipid and glucose concentrations. This, in turn, affects fetal growth, birth weight, and body surface area, as well as enhances placental transport capacity. The larger and heavier the placenta, the more optimal the nutrient transport to the fetus [56].

Pregnant women suffering from chronic energy deficiency (CED) will experience a deficiency in essential amino acids, glucose, and fats required for placental formation and fetal growth. An underdeveloped placenta leads to reduced nutrient and oxygen supply, thereby hindering fetal development. Inadequate fetal nutrient intake during pregnancy can result in poor birth anthropometry, such as low birth weight (LBW), reduced and small head circumference, as well as Small for Gestational Age (SGA) [57,58].

An excessive percentage of maternal body fat does not guarantee favorable neonatal anthropometry and may instead be associated with obesity. Obesity is a known risk factor for preeclampsia, a condition marked by elevated blood pressure. Pregnant women with hypertension may experience failure in the remodeling of spiral arteries, leading to placental ischemia, which in turn produces oxidative substances such as lipid peroxides. Elevated lipid peroxides reduce antioxidant levels, particularly vitamin E. As toxic oxidants or free radicals, lipid peroxides circulate in the bloodstream and damage endothelial cell membranes. This leads to the narrowing of placental blood vessels, thereby reducing the flow of blood and nutrients to the fetus, ultimately impairing fetal growth. Additionally, the inflammatory processes associated with preeclampsia may further disrupt fetal development and increase the risk of preterm birth [59].

A limitation of this study is that data on maternal BMI and MUAC were obtained from medical records during the last antenatal care (ANC) visit of the pregnancy. Collecting BMI and MUAC data prior to pregnancy would provide a more accurate reflection of the mother's nutritional status and serve as a better reference point for improving maternal nutrition throughout the gestational period.

5. Conclusion

The nutritional status profile of pregnant women who gave birth to low birth weight (LBW) infants at Arjowinangun and Ciptomulyo Public Health Centers in Malang City from January 2021 to July 2023 was predominantly within the normal range, with 30.47% having a Body Mass Index (BMI) between 18.5–22.9 kg/m^2 and 70.31% having a Mid-Upper Arm Circumference (MUAC) of ≥23.5 cm. Maternal BMI showed a very weak positive correlation with LBW, while maternal MUAC had no statistically significant association with LBW. This study provides insight into the association between maternal nutritional status and the incidence of low birth weight (LBW), and the findings are expected to serve as a basis for addressing nutritional problems in both pregnant women and infants.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflicts of interest.

Statement of ethical approval

Ethical approval was received from Ethics Committee of Universitas Airlangga (Approval No. 124/EC/KEPK/FKUA/2024).

Statement of informed consent

This study used medical records approved by the ethics committee; therefore, informed consent from patients was not required.

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