Amerta Nutrition
e-ISSN: 2580-1163 (Online)
p-ISSN: 2580-9776 (Print)
Anugerahwati et al. | Amerta Nutrition Vol. 8 Issue 3SP (December 2024). 208-217

RESEARCH STUDY
English Version

OPEN ACCESS

The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia

Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia

Ammara Asya Anugerahwati[1], Arif Sabta Aji[1], Effatul Afifah[1], Prasetya Lestari[2]*, Nur Indrawaty Lipoeto[3]

[1]Nutrition Department, Faculty of Health Sciences, Alma Ata University, Bantul, Daerah Istimewa Yogyakarta, Indonesia
[2]Midwifery Department, Faculty of Health Sciences, Alma Ata University, Bantul, Daerah Istimewa Yogyakarta, Indonesia
[3]Nutrition Department, Faculty of Medicine, Andalas University, Padang, Sumatera Barat, Indonesia

ARTICLE INFO

Received: *14-09-2024*
Accepted: *31-12-2024*
Published online: *31-12-2024*

****Correspondent:***
Prasetya Lestari
prasettya.lestari@almaata.ac.id

DOI:
10.20473/amnt.v8i3SP.2024.208-217

Available online at:
https://e-journal.unair.ac.id/AMNT

Keywords:
Interaction, Body Mass Index, Gestational Weight Gain, Newborn Anthropometry, Pregnancy

ABSTRACT

Background: Mother's nutritional status before and during pregnancy plays an important role in fetal growth and development. The prevalence of Low Birth Weight (LBW) incidence in West Sumatra has increased from 3.11% (2019) to 3.4% (2021).
Objectives: To analyze the interaction between pre-pregnancy BMI status and gestational weight gain on newborn anthropometry in West Sumatra.
Methods: This is a secondary data analysis study from the Vitamin D Pregnant Mother (VDPM) 2018 study with a prospective cohort design and the follow-up analysis was in February-April 2024. This study involved 175 pregnant women and newborns who met the predetermined criteria. Variables examined included pre-pregnancy BMI status, gestational weight gain, and newborn anthropometry. Data analysis used Kruskal Wallis, Spearman correlation test, and multivariate General Linear Model (GLM).
Results: Research findings showed a correlation between pre-pregnancy BMI and gestational weight gain (p-value 0.049, r=-1.4). Pre-pregnancy BMI correlated with birth weight (p-value=0.003, r=0.2) and body length (p-value=0.045, r=0.1), but not with head circumference (p-value=0.054). Gestational weight gain had no significant relationship with newborn anthropometry (p-value 0.512 for birth weight, p-value 0.368 for body length, and 0.368 for head circumference). No interaction was found between pre-pregnancy BMI and gestational weight gain status on newborn anthropometric measurements with a p-value of 0.739 for birth weight, 0.377 for body length, and 0.175 for head circumference.
Conclusions: The results show no interaction between pre-pregnancy BMI status and gestational weight gain on newborn anthropometry. Women are encouraged to pay attention to nutrition before and during pregnancy to optimize maternal and infant health.

INTRODUCTION

Health status can be measured using some parameters, including the nutritional condition of the population. Efforts to improve and increase the quality of public nutrition in Indonesia are ongoing programs and have received attention from the government. The 2018 Basic Health Research (Riskesdas) data indicate complex nutritional problems including stunting, wasting, and obesity, which are commonly referred to as the triple burden[1]. The Indonesian government aims to reduce the stunting rate from 24.4% in 2021 to 14% in 2024. *Gerakan Ibu Hamil Sehat* is a program that aims to break the chain of malnutrition in Indonesia[2]. Around 17.3% of pregnant women in this country suffer from Chronic Energy Deficiency (CED) as reported by the 2018 Riskesdas. In 2020, the prevalence of pregnant women with CED reached 9.7%, exceeding the target set for that year, namely 16%3. West Sumatra Province is actively involved in health efforts to optimize the health conditions of its population. Based on the 2018 Riskesdas data, the prevalence of pregnant women with CED in West Sumatra was 16.7%, exceeding the government's target in 2018 namely, 19.7%. Although exceeding the government's target, this rate increased compared to 2017, namely 14.5%4. Inadequate nutritional status in women during pregnancy has the potential to cause serious health consequences, including an increased likelihood of getting low birth weight (LBW) babies. This

How to cite: *Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.*

condition not only increases the risk of death in infants but also results in growth disorders, which are characterized by height that is not in line with the baby's age, which is called stunting. The Statistics Indonesia (BPS) reported that the incidence of LBW in West Sumatra was 0.2%. The incidence of Low Birth Weight (LBW) in the West Sumatra region fluctuated in the last few years. After experiencing an increase in 2019 and 2020 at a percentage of 2% and 3% respectively, there was a significant decrease of 0.2% in 2021. However, in 2022, the percentage increased again to 3.4%[5,6]. Prevention can be carried out by monitoring the nutritional status of pregnant women with regular anthropometric measurements covering height, pre-pregnancy weight, and pre-pregnancy BMI status[4]. Irawati et al (2014) argued that if gestational weight gain does not reach 9.1 kg, it can increase the possibility of giving birth to a baby weighing <3,000 g. LBW babies face a very high risk of mortality, namely 10-20 times greater than babies born with normal weight ranges[7].

Austrida Gondwel et al (2018) revealed that if pregnant women have poor nutritional status and gestational weight gain, they face a higher risk of having LBW babies. Low pre-pregnancy BMI contributes to a 60% increased risk of stunting in babies and gestational weight gain which is lower than the Institute of Medicine (IOM) recommendations poses a high risk of LBW and newborn's small head circumference[8]. LBW can affect the length of the baby and growth which leads to stunting[9]. The Statistics of Indonesia reported that the incidence of LBW in West Sumatera reached 0.2% in 2018. The trend of LBW incidence in West Sumatera has increased by 3.11% in 2019 and 3% in 2020. The incidence of LBW decreased 0.2% in 2021 and it increased again in 2022, namely 3.4%. Therefore, the incidence of LBW in West Sumatera is still fluctuating. Thus, more effective preventive efforts are needed to reduce the incidence of LBW and stop the increase in its prevalence. The 2018 Riskesdas Data revealed that in Sumatera, babies with birth weight <2500 g (LBW) were 4.6%. In terms of birth length, babies with a birth length of <33 reached 40.6% in Indonesia, while in West Sumatra it was 32%[1]. Pre-pregnancy BMI and gestational weight gain are key factors that influence maternal and fetal health conditions[10]. This study aims to identify the complex relationship between pre-pregnancy BMI status and gestational weight gain on anthropometric outcomes of newborns, covering weight, length, and head circumference in the West Sumatra region.

METHODS

This study utilized data from the Vitamin D Pregnant Woman (VDPM) study. The data were analyzed using a prospective cohort approach without conducting new data collection[11,12]. The study was conducted for six months from September 2017 to March 2018. Secondary data analysis was conducted for three months from February to April 2024 resulting in a final sample of 175 pairs of pregnant women and newborns who met the predetermined inclusion criteria. The sample was selected based on health checks at selected Puskesmas, with data collection in the first trimester (before 13 weeks) and the third trimester (after 27 weeks) of pregnancy. Each subject had to obtain a health certificate from a doctor, sign an informed consent, and be willing to undergo all study procedures. Additional criteria were pregnancy at an ideal term age (between 37-40 weeks) and a complete dataset from the VDPM Study. This is to ensure the quality and validity of the data where each pair of mothers and infants included met the predetermined standards. The VDPM study used two data collection methods, namely interviews and anthropometric measurements. Interviews covered demographic information, health, lifestyle, and medical history of pregnant women. Anthropometric measurement covered a series of detailed physical measurements, both for pregnant women and newborns. In pregnant women, measurements included weight, height, BMI, and mid-upper arm circumference (MUAC) to evaluate the nutritional status and maternal health. The anthropometric measurements of newborns covered weight, body length, and head circumference to assess the quality of fetal growth and development during the gestation period until birth. The data collection method in the following observations refers to secondary data obtained from the VDPM study in 2018, with details of the procedures presented in Figure 1. The selection of this research location considered the coverage of representative subjects based on geographic and demographic characteristics in West Sumatra Province, which includes coastal and mountainous areas, as well as urban and rural areas. This selection aims to ensure that variations in the characteristics of the research subjects can be fully reflected so that the research results can represent broader conditions in the area. The VPDM study was conducted in health facilities spread across five cities and districts in West Sumatra, namely Padang City, Pariaman City, Lima Puluh Kota District, Padang Pariaman District, and Payakumbuh City. The location selection criteria were based on significant geographic diversity, such as coastal areas which generally have different socio-economic conditions and access to health services compared to mountainous areas, as well as differences between more developed urban areas with better access to health facilities compared to rural areas which tend to have more limited access[13,14].

This study analyzed pre-pregnancy BMI status and gestational weight gain as independent variables. The dependent variables were anthropometric measurements covering birth weight, body length, and head circumference of newborns. This comprehensive analysis was mainly to explore and measure the direct impact of maternal nutritional status and health on the growth of the infant from pregnancy to birth. Pre-pregnancy BMI status is categorized into four groups, namely underweight, normal, overweight, and obese according to WHO guidelines in 2018[15]. Meanwhile, gestational weight gain is classified into three categories, namely underweight, normal, and overweight by considering the pre-pregnancy BMI status according to IOM[16]. Grouping of birth weight status in infants is divided into two main categories, namely LBW (<2500 g) and normal (≥2500 g). The birth length status is classified into two categories, namely short (<48 cm) and normal (≥48 cm). Then, the baby's head circumference is also

How to cite: *Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.*

grouped into two categories, namely small (<35 cm) and normal (≥35 cm).

This study used secondary data from the VDPM Study in 2018 in West Sumatra with the instrument of a questionnaire on sociodemographic data characteristics covering maternal age, location of residence in district/city, location based on geographic location and urban status, education and employment status of the mother, and monthly household income. The anthropometric measurement for mothers and newborns covered maternal weight before and during pregnancy, pre-pregnancy BMI status, total gestational weight gain, birth weight, birth length, and head circumference of the newborn. This study used a documentation study that utilized a dataset generated from the previous VDPM Study. The dataset contained data that were collected systematically covering various variables relevant to this study. This documentation study allows researchers to access and analyze secondary data to answer research questions without having to collect primary data directly. The datasets from the VDPM Study provide the advantage of access to verified and validated data which support the accuracy of the research results. The data collection process was started by obtaining official permission from the previous researcher, followed by downloading the dataset in .xlsx format via Google Drive. Data cleaning was carried out to correct possible errors. The variable identification stage involved grouping into independent variables (pre-pregnancy BMI status and gestational weight gain) and dependent variables (anthropometric measurement covering birth weight, birth length, and head circumference). This process also covered recategorizing variables according to research needs without changing the original data.

Data were analyzed univariately with the help of SPSS version 23 to describe the characteristics of each research variable. This method explains the data descriptively, including sociodemographic characteristics, pregnancy profiles, and maternal and infant anthropometry. The results of the univariate analysis were presented in various statistical formats including frequency distribution, proportion, median, interquartile range, and minimum and maximum values, which overall provide a detailed picture of the research subjects and the variables studied. The researcher carried out a bivariate analysis using the Kruskal-Wallis test and Spearman correlation to identify the relationship between variables.

This study used three statistical methods to analyze the data. A non-parametric test namely the Kruskal Wallis was carried out to analyze non-normally distributed categorical-numerical data, focusing on the comparison of medians between groups of variables, especially the relationship between pre-pregnancy BMI status, gestational weight gain, and newborn anthropometry. The test was considered significant if the p-value <0.05. Then, the Spearman correlation test was carried out to measure the strength and direction of the relationship between variables, especially the correlation in the independent and dependent variables with the significance criteria of p-values <0.05. A multivariate analysis using the General Linear Model (GLM) was conducted to identify the interaction of the relationship between maternal nutritional status before and during pregnancy with newborn anthropometry. This method considers various confounding factors such as maternal age, frequency of Antenatal Care (ANC) visits, age of birth, and parity, with a significance level of p-value <0.05. Through this multivariate approach, researchers can explore the effect of independent variables on the dependent variable while controlling for other factors that could potentially affect the results of the study.

This study has received ethical approval number KE/AA/V/10111637/EC/2024 from the Ethics Commission of Alma Ata University which was approved on 17 May 2024. In its implementation, this study adheres to strict research ethics principles including data use permits, which ensure that all data used in the observations have been accessed legally with appropriate approval from the relevant parties. In terms of transparency, the research process, data analysis, and research results are conveyed openly and clearly. This study also prioritizes data security by maintaining the confidentiality and integrity of the information obtained, so that research subjects and data involved are protected in accordance with applicable research ethics standards.

How to cite: Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.

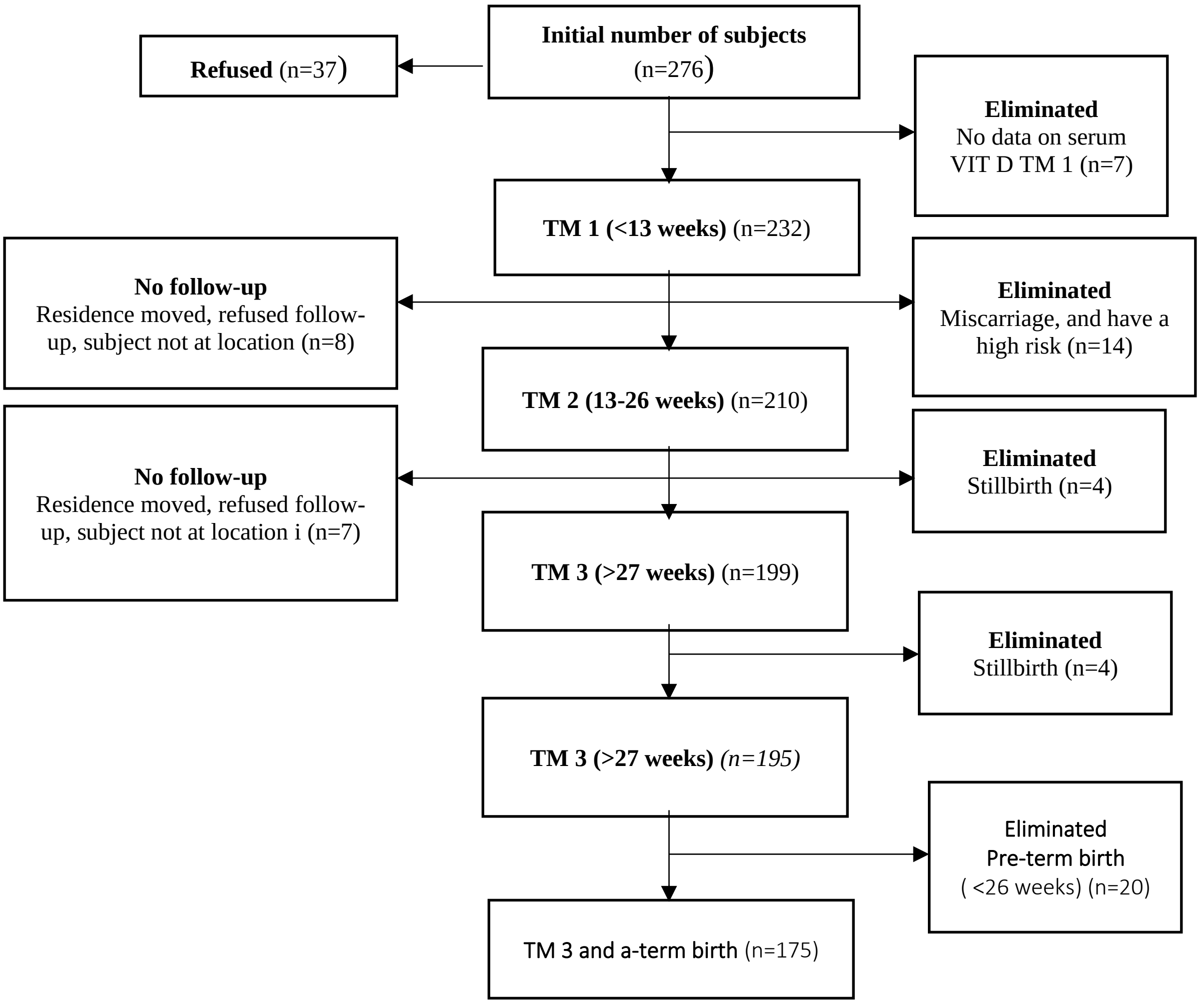

Figure 1. Procedures to Collect Research Subjects in the VDPM Cohort Study

RESULTS AND DISCUSSIONS

Sociodemographic Characteristics of Research Subjects

The pregnancy period is a sensitive and complex stage, where a some socio-demographic and personal variables play an important role in determining the quality and success of the reproductive process. Sulistyawati (2011) argues that the optimal reproductive age range with minimal risk is 20 to 35 years[17]. Pregnant women aged 20 years are not yet ready for reproductive organs and psychology, but those aged over 35 years are at risk of congenital disorders and birth complications. In this study, 15.4% of subjects are > 35 years[17]. Older mothers (> 35 years) face various risks due to reduced elasticity of the pelvic muscles which can result in the need for cesarean section[18].

Maternal education and income play an important role in fetal health and growth where higher education level and income can support a healthier pregnancy. Yuliva et al (2019) found that employed pregnant women had babies born with a weight of 129.23 g lower than unemployed pregnant women[19]. In this study, the majority of respondents had an income of IDR 2,250,000, lower than the Provincial Minimum Wage (UMP) in West Sumatera in 2018. Handayani et al (2024) argue that low income causes the inability to buy food which can result in the adequacy of nutrition for pregnant women which leads to the risk of having LBW babies[20]. Therefore, education and income play an important role in influencing maternal health and fetal growth. Both government and society need to increase awareness and efforts to improve the education and income of pregnant women[19,20].

Pregnancy profile can also influence the anthropometric outcome of newborns. Pregnancy profiles include gestational age and parity. In the early gestational age (<37 weeks), the fetal growth is not yet perfect which can result in LBW babies. LBW is divided into two, namely LBW due to pure prematurity and LBW due to dysmaturity. Pure prematurity occurs when the gestational age is <37 weeks and the baby's weight is in line with the age of birth. Meanwhile, dysmaturity is when birth weight is less than the actual weight at the gestational age. The older the gestational age, the more the baby's weight will increase proportionally[18]. Parity also influences the incidence of LBW babies. Islami and Noor (2020) found that the incidence of LBW occurs more in primiparas compared to multiparas mothers[21]. The theory states that someone who experiences repeated pregnancies is at higher risk of experiencing LBW births because pregnancy can damage blood vessels in the uterine wall and affect the circulation of nutrients to the fetus. Therefore, gestational age and parity are important

How to cite: Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.

factors in determining the anthropometry of the baby. Gestational age <37 weeks and high parity can lead to the incidence of LBW babies[21,22].

Anthropometric Characteristics of Mothers and Newborns

Table 1 shows that the median value of maternal weight before pregnancy was 55 kg (IQR 47-63 kg) and pre-pregnancy BMI status was 23.1 kg/m^2 (IQR 19.7-25.6 kg/m^2). Around 58.9% of subjects had normal nutritional status. Total gestational weight gain was 7.6 kg (IQR 5.4-9.8 kg) with 74.3% of subjects experiencing weight gain less than the recommendation. Anthropometric measurement in newborns showed that the median value of birth weight was 3200 g (IQR: 3000-3500 g) with a normal birth weight category of 95.4%. The median value of birth length was 49 cm (IQR; 48-50 cm) with a normal birth length category of 95.4%. Meanwhile, the median value of the baby's head circumference is 34 cm (IQR; 33-35 cm) and 74.3% had a normal head circumference category. For women with low BMI, weight gain tends to be more in the form of additional fat tissue, while for those with high BMI, weight gain is more related to fetal growth and fluid. Hormonal adaptation can be influenced by the production of hormone sensitivity related to metabolism and fat storage during pregnancy[23]. Mothers with normal pre-pregnancy BMI status (18.5-25 kg/m^2) give birth to babies weighing <2500 g (LBW)[24].

Sandra et al (2015) argue that weight gain can result in high-risk pregnancy. Poor maternal nutritional status during pregnancy can result in fetal growth retardation[25]. Mothers with malnutrition will experience decreased heart function which can lead to weak blood flow to the placenta and a reduced supply of important nutrients to the fetus. This condition can cause suboptimal fetal growth so the anthropometry of the baby is abnormal[26].

Table 1. Characteristics and Anthropometry of Mothers and Babies in West Sumatra, Indonesia in 2018 (N=175)

Variables	Percentage (%)	Median (IQR)	Min-Max
Maternal Age (year)		30.0 (25.0 -33.0)	17.0-44.0
Category of Maternal Age (year)			
<20	1.7		
20-35	82.8		
>35	15.4		
Educational Status			
Primary School	29.1		
Middle School	39.4		
Higher Education	1.4		
Household Income/Month (Rp)		2,250,000 (1,600,000-33,000,000)	280,000-48,000,000
Parity			
Nulliparous	22.2		
Primiparous	77.7		
Birth Age (weeks)		39.33 (38.0-40.0)	37.0-43.0
Pre-pregnancy BMI (kg/m^2)		23.1 (19.7-25.6)	14.10-36.5
Pre-pregnancy BMI Status			
Underweight	8.6		
Normal	58.9		
Overweight	14.3		
Obese	18.3		
Total Gestational Weight Gain (kg)		7.6 (5.4-9.8)	0.1-16.4
Gestational Weight Gain Status			
Underweight	74.3		
Normal	22.3		
Overweight	3.4		
Birth Weight (g)		3200.0 (3000.0-3500.0)	2100.0-4900.0
Birth Weight Status			
Low	4.6		
Normal	95.4		
Birth Length (cm)		49.0 (48.0-50.0)	35.0-55.0
Birth Length Status			
Short	4.6		
Normal	95.4		
Head Circumference		34.0.0 (33.0-35.0)	30.0-38.0
Head Circumference Status			
Small	25.7		
Normal	74.3		

ANC: Antenatal Care, IQR: Interquartile Rasio, BMI: Body Mass Index, BW: Body Weight, Low Birth Weight <2500 g, Normal Birth Weight ≥2500 g, Short Birth Length <48 cm, Normal Birth Length ≥48 cm, Small Head Circumference <35 cm, Normal Head Circumference ≥35 cm

How to cite: *Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.*

Relationship between Pre-pregnancy BMI Status and Gestational Weight Gain

Table 2 shows the results of the Kruskal-Wallis test with a significant relationship to the median value difference in pre-pregnancy BMI status and gestational weight gain (p-value=0.049). There is a difference in the median value of total gestational weight gain in women with pre-pregnancy BMI status of thin and fat, and fat and normal. Based on the Spearman correlation analysis, there is no significant relationship between pre-pregnancy BMI status and total gestational weight gain (p-value=0.52). The correlation (r) between pre-pregnancy BMI status and gestational weight gain is -1.42 indicating a very strong correlation between the two variables. However, they have a negative direction where the larger the BMI category, the smaller the total gestational weight gain. Radhakanta et al (2017) found that obese mothers tend to experience excessive weight gain, while mothers with low BMI are at risk of underweight gain, both of which can have a negative impact on pregnancy. Pre-pregnancy BMI was statistically proven to be associated with gestational weight gain (p-value <0.001). The energy needs of pregnant women are influenced by BMI. Low BMI requires more additional energy, while high BMI requires less[27]. BMI also affects basal metabolic rate and hormonal adaptations related to metabolism during pregnancy. Weight gain patterns differ between women with low and high BMI, with different implications for fat tissue, fetal growth, and body fluids[23].

Table 2. Relationship between Pre-pregnancy BMI Status and Gestational Weight Gain in 2018 (N=175)

Pre-pregnancy BMI Status	Frequency (n)	Total Gestational Weight Gain (kg)	p-value	Correlation (r)	^a^p-value
Underweight	15	8.4 (5.4-12.6)	0.04*	-1.4	0.52
Normal	103	9.1 (2.0-15.0)			
Overweight	25	6.8 (3-14.3)			
Obese	32	8.4 (4-13.8)			

*) Kruskal-Wallis test, significant if p-value<0.05, Post hoc Mann Whitney test, Underweight vs Normal weight p-value>0.05; Underweight vs overweight p-value=0.021; underweight vs obese p-value>0.05; Normal vs overweight p-value=0.009; Normal vs obese p-value>0.05; overweight vs obese p-value>0.05, [a]) Spearman Correlation test

The Relationship between Pre-pregnancy BMI and Anthropometrics of Newborns

Table 3 shows a significant relationship between pre-pregnancy BMI and birth weight (Kruskal-Wallis p-value=0.003; Spearman p-value=0.009). Differences in the median value of birth weight were found between the underweight-normal, underweight-obese, and normal-obese BMI groups. The correlation was very weakly positive (r=0.2). There is also a significant association between pre-pregnancy BMI and birth length (Kruskal-Wallis p=0.045). Differences in the median value of birth length were found between the underweight-normal and underweight-obese BMI groups. However, Spearman's correlation was not significant (p-value=0.1) with a very weak correlation (r=0.106). BMI status and head circumference did not show a significant relationship (Kruskal-Wallis p-value=0.054; Spearman p-value=0.124) with a very weak correlation (r=0.117). Mothers with low BMI are at higher risk of giving birth to LBW babies, with a global prevalence of 15-20% per year as reported by WHO. Risk factors for LBW cover poor maternal nutritional intake, low BMI status, and CED in women[28]. Irma (2019) revealed a significant association between pre-pregnancy BMI and birth weight (p-value=0.040, r=0.232). Eka and Sandra (2016) also found that the nutritional status of mothers with a low pre-pregnancy BMI has an 11.6 times higher risk of giving birth to LBW babies compared to those with a normal BMI[24].

Pre-pregnancy BMI status has a significant relationship to birth length in line with a previous study at Puskesmas Padamara, Purbalingga District that BMI status has a very strong and significant relationship to the birth length of babies (p-value <0.001, r=0.876). The greater the pre-pregnancy BMI status, the greater the birth length of the baby[29]. Pre-pregnancy BMI status does not have a significant relationship to head circumference. This is in line with a previous study by Nentien and Sri (2018) in the Obstetrics Room of RSI Ibu Sina Bukit Tinggi with a sample of 202 people that reveals an insignificant result between pre-pregnancy BMI status and head circumference (p-value=0.120), with an average head circumference of 32.9 cm[30]. Head circumference is an indicator of fetal growth and baby health. The head circumference sizes can be influenced by many factors, namely genetics, microcephaly, hydrocephalus, and cerebral tumors. Besides, the head circumference can also be influenced by indirect factors such as maternal age, parity, maternal hemoglobin, and maternal lifestyle[31]. Diet and nutritional intake before pregnancy affect early pregnancy nutritional status which also affects infant outcomes. Morning sickness can reduce food intake and this affects maternal weight gain. Hormonal and metabolic changes during pregnancy interact with pre-pregnancy BMI, affecting weight gain patterns. Women with low BMI who experience severe morning sickness require special attention to ensure adequate weight gain[32].

Table 3. Relationship between Pre-pregnancy BMI and Anthropometrics of Newborns and Interaction between Pre-pregnancy BMI and Gestational Weight Gain on Anthropometric of Newborns in 2018

Variable	Percentage (%)	Median (IQR)	p-value	P Interaction
Birth Weight (g)				
Underweight	8.6	3000.0 (2100.0-3500.0)	0.003[a]*	0.739[30d]

How to cite: *Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.*

Variable	Percentage (%)	Median (IQR)	p-value	P Interaction
Birth Weight (g)				
Normal	58.9	3200.0 (2100.0-4500.0)	0.2[b]	
Overweight	14.3	3100.0 (2400.0-4000.0)	0.009[c]*	
Obese	18.3	3400.0 (2600.0-4900.0)		
Birth Length (cm)				
Underweight	8.6	48.0 (45.0-50.0)	0.045[a]*	
Normal	58.9	49.0 (35.0-55.0)	0.1[b]	0.377[d]
Overweight	14.3	48.0 (47.0-51.0)	0.161[c]	
Obese	18.3	50.0 (45.0-53.0)		
Head Circumference (cm)				
Underweight	8.6	35.0 (30.0-37.0)	0.054[a]	
Normal	58.9	34.0 (30.0-38.0)	0.1[b]	0.175[d]
Overweight	14.3	34.0 (30.0-36.0)	0.124[c]	
Obese	18.3	35.0 (31.0-38.0)		

Data are presented in median (Interquartile Range), [a]) Kruskal-Wallis test, [b]) r value from Spearman's correlation test, [c]) p-value from Spearman's correlation test, [d]) Multivariate analysis used general linear model test with a total of 175 samples, *) Significant if p-value<0.05, Adjustment for confounding factors/variables used are maternal age, ANC visits, gestational age, and parity status and the p-value used is the p-value for interaction results.

Relationship between Gestational Weight Gain and Anthropometrics of Newborns

Table 4 shows that gestational weight gain has no significant correlation with anthropometric measurements of newborns covering birth weight, body length, and head circumference. The Kruskal-Wallis test obtained a p-value>0.05 for all three variables (body weight: p-value=0.512; body length: p-value=0.368; and head circumference: p-value=0.273), indicating no significant median difference. Spearman correlation analysis also confirmed that there is no significant association, with a p-value of >0.05 and a very weak correlation coefficient (r) for all variables (body weight: p-value=0.340, r=0.1; body length: p-value=0.713, r=-0.3; and head circumference: p-value=0.078, r=0.1). Based on the analysis, the association between gestational weight gain and anthropometric outcomes of newborns did not show a significant correlation. This finding is consistent with a previous study by Akbar Shiddiq (2011) in Pariaman City that there was no significant correlation between gestational weight gain and birth weight (p-value=0.32)[33]. This is in line with a previous study by Rosdianto et al (2019) at the Sukabumi Basic Emergency Obstetric Neonatal Care (PONED) involving 72 samples. Postpartum mothers expressed that gestational weight gain in the early and late stages of pregnancy (trimesters I and III) did not show a significant correlation with the anthropometric outcomes of newborns. Specifically, gestational weight gain in the third trimester did not show a significant relationship with the baby's body length, and likewise gestational weight gain in the first trimester did not have a significant relationship with the baby's head circumference. These findings highlight the complexity of factors influencing fetal growth[34].

Gestational weight gain reflects nutritional status and needs to be monitored regularly. Increases that are not in accordance with IOM recommendations can indicate malnutrition and the risk of fetal growth disorders. Factors influencing weight gain include fetal growth, placenta, amniotic fluid, enlargement of maternal organs, and changes in metabolism. Maternal nutritional status has a significant influence on pregnancy outcomes. Malnutrition can inhibit fetal growth and increase the risk of LBW and stunting. On the other hand, balanced nutrition supports optimal fetal growth and reduces the risk of complications[35]. During pregnancy, energy needs increase by 300-500 kcal/day in the second and third trimesters. Carbohydrate, protein, and fat metabolism change to support fetal growth and prepare for breastfeeding. Moreover, considering micronutrient intake such as folic acid, iron, and calcium, is also important. Optimal total weight gain of 11-16 kg supports healthy fetal growth and minimizes the dangers of premature birth or LBW[16].

Table 4. Relationship between Gestational Weight Gain and Anthropometry Outcomes in 2018

Variable	Percentage (%)	Median (IQR)	[a]p-value	R	[b]p-value
Birth Weight (g)					
Underweight	74.3	3200.0 (2100.0-4500.0)			
Normal	22.2	3300.0 (2400.0-4900.0)	0.512	0.1	0.340
Overweight	3.4	3200.0 (2400.0-3500.0)			
Birth Length (cm)					
Underweight	74.3	49.0 (35.0-55.0)			
Normal	22.2	49.0 (45.0-53.0)	0.368	-0.3	0.713
Overweight	3.4	48.0 (45.0-51.0)			
Head Circumference (cm)					
Underweight	74.3	49.0 (35.0-55.0)	0.368	-0.3	0.713
Normal	22.2	49.0 (45.0-53.0)			

How to cite: Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.

Variable	Percentage (%)	Median (IQR)	[a]p-value	R	[b]p-value
Overweight	3.4	48.0 (45.0-51.0)			

Data are presented in median (minimum-maximum), [a])Kruskal-Wallis test, significant if p-value<0.05, [b]) Spearman Correlation Test, significant if p-value<0.05

Interaction between Pre-pregnancy BMI Status and Gestational Weight Gain on Anthropometrics Outcomes

Table 3 shows the results of multivariate analysis using the General Linear Model with an interaction test on pre-pregnancy BMI status and gestational weight gain on anthropometry outcomes (weight, length, and head circumference). The analysis considers covariate variables such as maternal age, total ANC visits, birth age, and parity. The results showed no significant interaction for all infant anthropometric outcomes: birth weight (p-value=0.739), birth length (p-value=0.377), and head circumference (p-value=0.175). The results of the study showed that pre-pregnancy BMI status and gestational weight gain did not cause a significant interaction effect on the size of the baby's growth at birth, after considering various relevant comparison variables.

The findings of this study are in line with a previous study by Frederick et al (2008) that there was no interaction between pre-pregnancy BMI and gestational weight gain on birth weight (p-value=0.645). The nutritional status of the mother before and during pregnancy greatly influences the outcome of the baby. Mothers with normal nutrition tend to give birth to babies with normal weight and full term. Malnutrition increases the risk of LBW and premature birth, while obesity can cause complications such as miscarriage, preeclampsia, and macrosomia. However, other factors such as maternal age, education, parity, gestational age, and gender of the baby also contribute to the baby's birth weight[36,37]. Moreover, Fitri and Wiji (2018) revealed that nutrient intake plays an important role in the anthropometry of newborns. Pregnant women need to monitor their nutritional intake and status to prevent deficiencies that can cause malnutrition and stunting impacting the child's cognitive development, growth, and long-term health. Pre-pregnancy BMI reflects the mother's long-term nutritional status, while gestational weight gain reflects nutrient intake and metabolic adaptation. Maternal nutrient intake and adequacy affect placental development and nutrient transfer from mother to fetus. Macronutrient and micronutrient adequacy an important role in fetal growth, affecting birth weight, length, and head circumference[38].

Nutritional interactions indicate that a low BMI and inadequate weight gain can increase the risk of nutritional deficiencies, while a high BMI with excessive weight gain can increase insulin resistance. Normal BMI with optimal weight gain can support optimal fetal growth. Long-term nutritional implications show that birth anthropometry can affect growth patterns and the risk of metabolic diseases later in life. Therefore, pregnant women need to prepare for their pregnancy by maintaining their pre-pregnancy BMI status and appropriate gestational weight gain and considering other factors to reduce the risk of having a baby with suboptimal anthropometry[39].

The limitation of this study is the data source which comes from secondary data so the level of generalization of the research results is quite high. Future studies are expected to analyze primary data so that the results obtained can represent the conditions obtained when the research is conducted. Besides, this study did not examine in more depth the types of nutritional intake, environmental conditions, and other factors that can affect them. Thus, future studies are expected to consider and analyze them.

CONCLUSIONS

Based on the results of the study, it can be concluded that there is a significant relationship between BMI status before pregnancy and gestational weight gain. BMI before pregnancy also correlates with the weight and birth length of the baby, but not with head circumference. Gestational weight gain does not show a significant relationship in the anthropometry of the newborn, including weight, length, and head circumference. However, there is no significant interaction between BMI before pregnancy and gestational weight gain on the anthropometry of the newborn.

ACKNOWLEDGEMENT

The author highly appreciates all parties who have participated in completing this observation. The author also appreciates the VDPM (Vitamin D Pregnant Woman) research team for giving permission to analyze their secondary data. The author also appreciates fellow researchers in the Pregnant Women Nutrition Research Group for their constructive discussions.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The author confirms that no conflict of interest could affect the objectivity of this scientific article. In addition, this study was conducted without external funding support and used available secondary data, thus ensuring the authenticity and credibility of the research results.

AUTHOR CONTRIBUTIONS

ASA: conceptualization and research design, and reviewing and revising the manuscript; NIL: conceptualization and research design; PL: reviewing and revising the manuscript; EF: reviewing and revising the manuscript; AAA: research data analysis, preparing the initial manuscript. All authors have approved the final version of the manuscript.

REFERENCES

1. Riskesdas Sumatra Barat. *Riset Kesehatan Dasar Provinsi Sumatera Barat Tahun 2018*. *Laporan Riskesdas Nasional 2018* (2018).
2. Kementrian Kesehatan RI. *Gerakan Ibu Hamil Sehat untuk Turunkan Stunting dan Angka*

Kematian Ibu. https://www.kemkes.go.id/article/view/22121300004/gerakan-ibu-hamil-sehat-untuk-turunkan-stunting-dan-angka-kematian-ibu.html (2022).
3. Kementrian Kesehatan RI. *Laporan Kinerja Kementrian Kesehatan Tahun 2020*. (Kementrian Kesehatan RI, 2021).
4. Kemenkes RI. *Laporan Nasional Riskesdas 2018*. *Badan Penelitian dan Pengembangan Kesehatan* (2018).
5. BPS Provinsi Sumatera Barat. *Provinsi Sumatera Barat dalam Angka Sumatera Barat Provinces in Figures 2019*. (2019).
6. BPS Provinsi Sumatera Barat. Provinsi Sumatera Barat dalam Angka Sumatera Barat Provinces in Figures 2020. (2020).
7. Irawati, A. & Susilowati, A. Antropometri Wanita Pra Hamil dan Pengaruhnya Pada Pertambahan Berat Badan Selama Kehamilan Di Kecamatan Bogor Tengah, Kota Bogor. *Gizi Indonesia*. **37**, 109 (2014). doi: https://doi.org/10.36457/gizindo.v37i2.156
8. Gondwe, A. *et al.* Pre-Pregnancy Body Mass Index (BMI) and Maternal Gestational Weight Gain are Positively Associated with Birth Outcomes in Rural Malawi. *PLoS One* **13**, (2018). doi: https://doi.org/10.1371/journal. pone.020603
9. Badan Pusat Statistik. *Profil Kesehatan Ibu dan Anak 2020*. (Badan Pusat Statistik, 2020).
10. Yongky, Y., Hardinsyah, H., Gulardi, G. & Marhamah, M. Status Gizi Awal Kehamilan dan Pertambahan Berat Badan Ibu Hamil Kaitannya dengan BBLR. *J. Gizi dan Pangan* **4**, 8 (2009). doi : https://doi.org/10.25182/jgp.2009.4.1.8-12
11. Aji, A. S. *et al.* Impact of Maternal Dietary Carbohydrate Intake and Vitamin D-related Genetic Risk Score on Birth Length: the Vitamin D Pregnant Mother (VDPM) Cohort Study. *BMC Pregnancy Childbirth* **22**, 690 (2022). doi: https://doi.org/10.1186/s12884-022-05020-3
12. Aji, A. S., Yusrawati, Y., G Malik, S. & Lipoeto, N. I. The Association of Maternal Vitamin D Status during Pregnancy and Neonatal Anthropometric Measurements: A Longitudinal Study in Minangkabau Pregnant Women, Indonesia. *J. Nutr. Sci. Vitaminol. (Tokyo).* **66**, S63–S70 (2020). doi: https://doi.org/10.3177/jnsv.66.S295
13. Aji, A. S. *et al.* A Genetic Approach to Study the Relationship between Maternal Vitamin D status and Newborn Anthropometry Measurements: the Vitamin D Pregnant Mother (VDPM) Cohort Study. *J. Diabetes Metab. Disord.* **19**, 91–103 (2020). doi: https://doi.org/10.13140/RG.2.2.21860.91522
14. Aji, A. S., Yusrawati, Y., Malik, S. G. & Lipoeto, N. I. The Association between Vitamin D-Related Gene Polymorphisms and Serum 25-Hydroxyvitamin D Concentration: A Prospective Cohort Study in Pregnant Minangkabau Women, Indonesia. *J. Nutr. Sci. Vitaminol. (Tokyo).* **66**, S295–S303 (2020). doi: https://doi.org/10.3177/jnsv.66.S295
15. Cut-off for BMI according to WHO standards. *World Health Organization* (2018).
16. Institute of Medicane. *Weight Gain During Pregnancy : Reexamining The Guidlines*. (National Academy Press, 2009).
17. Sulistyawati, A. *Asuhan Kebidanan Pada Masa Kehamilan. Jakarta: Salemba medika*. (Selemba Medika, 2011).
18. Suciyanti & Afifah, E. Gambaran Karakteristik Ibu Bersalin sectio Caesarea di RSUD Panembahan Senopati Bantul. (Universitas Alma Ata, 2015).
19. Yuliva, Ismail, D. & Rumekti, D. Hubungan Status Pekerjaan Ibu dengan Berat Lahir Bayi Di RSUP Dr. M. Djamil Padang. *Ber. Kedokt. Masy.* **25**, 1–13 (2019). doi: https://doi.org/10.22146/bkm.3570
20. Handayani, Baety, N. & Utami, Y. Hubungan Demografi Ibu dengan Kejadian Bayi Berat Lahir Rendah (BBLR) di Rumah Sehat untuk Jakarta. **3**, 1–12 (2024). doi: https://doi.org/10.54771/yj8wtr72
21. Islami & Cholifah, N. Hubungan antara Umur, PAritas, Riwayat Penyakit dan Status Gizi dalam Kehamilan dengan Kejadian BBLR di RSI Sultan Hadrilin Jepara. *J. Univeritas Muhammadiyah Kudus* **4**, 125–129 (2020). doi: https://doi.org/10.26751/ijb.v1i2.1191
22. Rahmat, B., Aspar, H., Masse, M. & Risna, R. Faktor-Faktor Yang Berhubungan Dengan Kejadian Bayi Berat Lahir Rendah (BBLR) Di Rumkit Tk II Pelamonia Makassar Tahun 2019. *J. Kesehat. Delima Pelamonia* **3**, 72–79 (2019). doi: https://doi.org/10.37337/jkdp.v3i1.123
23. Chen, Z. *et al.* Prepregnancy body mass index, gestational weight gain, and pregnancy outcomes in China. *Int. J. Gynaecol. Obstet. Off. organ Int. Fed. Gynaecol. Obstet.* **109**, 41–44 (2010). doi: https://doi.org/10.1016/j.ijgo.2009.10.015
24. Puspita, I. M. Hubungan Antara Indeks Massa Tubuh (Imt) Ibu Prahamil dan Kenaikan Berat Badan Selama Kehamilan dengan Berat BAdan Lahir Bayi di RSUD DR. M. Soewandhie Surabaya. *Midwifery J. | Kebidanan* **4**, 32–37 (2019). doi: https://doi.org/10.31764/mj.v4i2.946
25. Fikawati, S., Syafiq, A. & Karima, K. *Gizi Ibu dan Bayi*. (Raja Grafindo Persada, 2015).
26. Nurhayati, E. & Fikawati, S. Indeks Massa Tubuh (IMT) Pra Hamil dan Kenaikan Berat Badan Ibu Selama Hamil Berhubungan dengan Berat Badan Bayi Lahir. *J. Ners dan Kebidanan Indones.* **4**, 1 (2016). doi: https://doi.org/ 10.21927/jnki.2016.4(1)
27. Pal, R., Maiti, M., Roychoudhury, B., Sanyal, P. & Chowdhury, B. Women on the Side of War and and Poverty : Its Effect Association of Other Pregestational BMI Antenatal on the Health of Reproduction Weight Gain With Pregnancy Outcome : A Prospective. *Aras Part Med. Int. Press* **5**, 37–40 (2017). doi: http://dx.doi.org/10.15296/ijwhr.2017.07
28. Putri, M. C. Hubungan Asupan Makan dengan Kejadian Kurang Energi Kronis (KEK) pada Wanita Usia Subur (WUS) di Kecamatan Terbanggi Besar Kabupaten Lampung Tengah. (Universitas Lampung, 2019).

How to cite: *Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.*

29. Ningrum, E. W. & Cahyaningrum, E. D. Status Gizi Pra Hamil Berpengaruh terhadap Berat dan Panjang Badan Bayi Lahir. *Medisains* **16**, 89 (2018). doi: https://doi.org/10.30595/medisains.v16i2.3007
30. Destri, N. & Hayulita, S. Pengaruh Indeks Masa Tubuh (IMT) Sebelum Hamil dan Kenaikan Berat Badan Dalam Kehanilan dengan Antropometri Bayi Baru Lahir. *J. Kesehat. Med. Saintika* **9**, (2018). doi: http://dx.doi.org/10.30633/jkms.v9i2.237
31. Rahman, H., Nulanda, M., Nurmadilla, N., Dewi, A. S. & Darma, S. Analisis Status Gizi Ibu Sebelum Hamil Terhadap Pemeriksaan Antropometri Luaran Bayi Baru Lahir Di Rumah Sakit Nenemallomo Kabupaten Sidenreng Rappang Sulawesi Selatan. **4**, 5492–5508 (2024). doi: https://doi.org/10.31004/innovative.v4i3.9998
32. Yazdani, S., Yosofniyapasha, Y., Nasab, B. H., Mojaveri, M. H. & Bouzari, Z. Effect of Maternal Body Mass Index on Pregnancy Outcome and Newborn Weight. *BMC Res. Notes* **5**, 34 (2012). doi: https://doi.org/10.1186/1756-0500-5-34
33. Shiddiq, A., Lipoeto, N. I. & Yusrawati. Hubungan Pertambahan Berat Badan Ibu Hamil terhadap Berat Bayi Lahir di Kota Pariaman. *Jurna Kesehat. Andalas* **4**, (2015). doi: https://doi.org/10.25077/jka.v4i2.276
34. Octascriptiriani Rosdianto, N., Herman, H. & Murniati, V. Hubungan Antara Penambahan Berat Badan Ibu Selama Hamil Dengan Antropometri (Berat Badan, Panjang Badan, Lingkar Kepala) Bayi Baru Lahir. *J. Kebidanan* **5**, 317–323 (2019). doi: https://doi.org/10.33024/jkm.v5i4.1879
35. Mazurek, D. & Bronkowska, M. Maternal Anthropometric Factors and Circulating Adipokines as Predictors of Birth Weight and Length. *Int J Env. Res Public Heal.* **17**, (2020). doi: https://doi.org/10.3390/ijerph17134799
36. Frederick, I. O., Williams, M. A., Sales, A. E., Martin, D. P. & Killien, Ma. Pre-Pregnancy Body Mass Index, Gestational Weight Gain, and other Maternal Characteristics in Relation to Infant Birth Weight. *Matern. Child Health J.* **12**, 557–567 (2008). doi: https://doi.org/10.1007/s10995-007-0276-2
37. Yusridawati, Y. Faktor-Faktor Yang Mempengaruhi Kejadian Bayi Berat Badan Lahir Rendah (BBLR) Di RSUD Kota Pinang Kabupaten Labuhan Batu Selatan Tahun 2021. *J. Kebidanan, Keperawatan Dan Kesehat.* **1**, 57–62 (2021). doi: https://doi.org/10.51849/j-bikes.v1i2.9
38. Fitri, I. & Wiji, R. N. Asupan zat gizi makro dan kenaikan berat badan selama hamil terhadap luaran kehamilan. *J. Gizi Klin. Indones.* **15**, 66 (2018). doi: https://doi.org/10.22146/ijcn.39163
39. Papachatzi, E., Dimitriou, G., Dimitropoulos, K. & Vantarakis, A. Pre-Pregnancy Obesity: Maternal, Neonatal and Childhood Outcomes. *J. Neonatal. Perinatal. Med.* **6**, 203–216 (2013). doi: https://doi.org/10.3233/NPM-1370313

How to cite: *Anugerahwati, A. A., Aji, A. S., Afifah, E., Lestari, P., & Lipoeto, N. I. (2024) The Interaction between Pre-Pregnancy Body Mass Index Status and Gestational Weight Gain on Newborn Anthropometry Outcomes in West Sumatera, Indonesia: Interaksi antara Status Indeks Massa Tubuh sebelum Hamil dan Kenaikan Berat Badan selama Hamil terhadap Antropometri Bayi Lahir di Sumatera Barat, Indonesia. Amerta Nutrition, 8(3SP), 208–217.*