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Maternal determinants of average weekly fetal weight gain in Yogyakarta, Indonesia

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ABSTRACT

Average fetal weight gain (AWG) is one of the important parameters usually used as an indicator to identify the fetal risk of poor outcomes of intrauterine growth restriction (IUGR) or macrosomia. This study aimed to investigate the association between AWG and maternal factors such as body weight (BW), body mass index (BMI), middle-upper arm circumference (MUAC), and economic status in Yogyakarta, Indonesia. This community-based cross-sectional study was conducted in one district in the Yogyakarta Special Province, Indonesia. The study included 50 mother-infant pairs who delivered at term (37-42 weeks of pregnancy). The mother's BW, height, BMI, and MUAC were recorded using a case-report form. Questionnaires were also completed to establish the respondents' economic status. Maternal factors associated with fetal birth weight were determined using univariate and multivariate analyses. The mothers registered in our study mostly had good nutritional status (74.0% had an optimal MUAC > 23cm). The mean AWG and birth weights were 172.6 ± 24.5g/wk and 3.08 ± 0.34kg, respectively. Univariable analysis models were used to assess the associations between each variable and AWG (with a cut-off value of 153.8 g/wk). Our study found no associations between higher MUAC and higher AWG (OR=1.03; 95% CI: 0.83-1.27; p=0.77) and energy intakes per day with AWG (OR=1.0; 95% CI: 1.00-1.001; p=0.21). Socioeconomic factors such as the mother's educational background also showed no association with AWG (OR=0.38; 95% CI: 0.92-1.57; p=0.18). In conclusion, this finding shows that there is no association between variables such as MUAC, mother's age, energy intake, and educational background with the average fetal weight gain achieved.

Keywords:
average fetal weight gain; middle-upper arm circumference; socioeconomic factors; low birth weight; intra uterine growth restriction

ABSTRACT

Rerata pertambahan berat badan janin (BBJ) adalah salah satu parameter penting yang dapat digunakan sebagai indikator untuk mengidentifikasi janin yang memiliki risiko luaran buruk seperti *intra uterine growth restriction* (IUGR) atau makrosomia. Penelitian ini bertujuan untuk melakukan studi menilai hubungan antara faktor maternal seperti berat badan, asupan energi harian, lingkar lengan atas (LILA), dan status ekonomi terhadap rerata pertambahan BBJ di populasi ibu hami di Yogyakarta, Indonesia. Penelitian ini merupakan penelitian potong lintang berbasis komunitas yang dilakukan di salah satu kabupaten di Daerah Istimewa Yogyakarta. Penelitian ini melibatkan 50 ibu hamil yang melahirkan secara aterm (37-42 minggu). Berat badan dan tinggi badan serta LILA ibu dicatat dalam form laporan. Kuesioner juga diberikan kepada partisipan untuk menilai status ekonomi dan pendidikan pasien. Faktor maternal yang berkaitan dengan berat badan janin dianalisis secara univariat dan multivariat. Sebagian besar ibu hamil memiliki status nutrisi yang cukup (74% memiliki LILA optimal > 23cm) pada saat proses rekrutmen partisipan penelitian. Rerata pertambahan BBJ dan berat badan lahir (BBL)

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secara berurutan adalah 172,6 ± 24,5g/minggu dan 3,08 ± 0,34kg. Analisis univariat untuk menganalisis hubungan antar variabel dan rerata BBJ (dengan nilai ambang 153,8g/minggu). Dalam penelitian ini didapatkan adanya hubungan namun secara statistik tidak signifikan antara besarnya LILA (OR=1,03; 95% CI: 0,83-1.27; p=0,77) dan asupan energi harian (OR=1,0; 95% CI: 1,00-1,001; p=0,21) dan besarnya rerata kenaikan BBJ. Faktor sosioekonomi dan latar belakang pendidikan juga tidak menunjukan hubungan yang signifikan terhadap rerata kenaikan BBJ (OR=0,38; 95% CI: 0,92-1,57; p=0,18). Dapat disimpulkan, tidak ada hubungan antara faktor maternal seperti LILA, usia maternal, asupan energi, dan latar belakang pendidikan terhadap rerata kenaikan BBJ.

INTRODUCTION

Low birth weight (LBW) is a major public health problem, especially in developing countries. Several studies confirmed that LBW is strongly associated with a higher risk of neonatal death, stunting, lower academic performance, mental health, and some non-communicable diseases (NCDs) including type 2 diabetes mellitus, hypertension, and cardiovascular diseases (CVDs) in later life.[1–5] The global prevalence of LBW is estimated at 14.6 to 20% of all live births, of which almost 95.6% are in developing countries. It is also associated with 60 to 80% of neonatal deaths worldwide.[6] The prevalence of LBW in Indonesia itself is relatively low. However, the number has been fluctuating between 2007-2018, from 5.4 to 6.2%.[7] Several risk factors are associated with LBW including lower pre-gestational weight, fewer antenatal care (ANC) visits, poor gestational weight gain, lower mother's educational status, mother's aged <18 and >35 years old, and presence of comorbidity during pregnancy.[8-10]

The measurement of average fetal weight gain (AWG) in association with maternal gestational weight gain (GWG) plays a significant role in the early identification of newborns who are at risk of adverse outcomes such as neonatal LBW, intrauterine growth restriction (IUGR), large for gestational age (LGA), and fetal macrosomia.[11] This measurement can be used to predict the occurrence of LBW.[12] However, the use of this method to facilitate antenatal screening for the IUGR or LGA fetus remains uncommon in clinical practice compared to other parameters such as GWG,[13,14] fundal height, and estimated fetal weight (EFW).[15] This is probably because AWG is relatively unpractical and several guidelines does not incorporate this parameter to be assessed routinely.[16,17] Regardless of the parameters that are being examined, it is important to detect abnormal growth patterns in the antenatal period, to predict and prevent adverse neonatal outcomes including LBW and stillbirth.

According to the National Institute of Child Health and Human Development (NICHD) fetal growth studies (n = 1,733) from 12 United States sites, the AWG calculated after 20wk of gestational age was in the range of 117 to 215g/wk with a mean of 175g/wk.[18] Data from the Australian population (n = 12,425) showed an almost similar range for the AWG from 130 to 225.6g/wk.[12] For the Asian population, the range is smaller than Caucasian infants. A study conducted by Uehara *et al.*,[19] in the Japanese population (n = 144,980) found the AWG was in the range of 133 to 175.7g/wk with a median value of 153.8g/wk.

The estimation of fetal growth using ultrasound parameters in combination with maternal anthropometric parameters (i.e. body mass index/ BMI, MUAC) has been shown to have promising and consistent results with neonatal outcomes.[18,20] This study aimed to calculate average fetal weight gain in the Javanese sub-population which

was derived from birth weight and gestational age at term.

MATERIALS AND METHODS

Design and subjects

This community-based cross-sectional study was conducted in one district in the Yogyakarta Special Province, Indonesia. The subjects were enrolled consecutively. We included subjects with a) the second trimester in gestational age; b) low- and middle-income economic status (regional minimum wage below standard <IDR 1,701,000/monthly); c) maternal age below 25 yo; and d) educational background below/equal to senior high school. We excluded subjects with concomitant diseases a) anemia; b) pre-eclampsia and eclampsia; and c) multiple gestations.

Procedure

The current study included 50 mother-infant pairs who delivered at term (37-42 weeks of pregnancy). The mother's BW, height, BMI, total energy intake/day, and MUAC were recorded using a case-report form. Questionnaires were also completed to establish the respondents' economic status. Maternal factors associated with fetal birth weight were determined using univariate and multivariate analyses.

Measurement of total energy intake/day was performed using the semi-quantitative food frequency questionnaire (SQ-FFQ) by direct interviews with the subjects. We calculated the AWG using the formula proposed by Mongelli *et al.*,[12] which divides the difference between fetal birth weight (BWT) and the 24-week median fetal weight by the difference between gestational age at birth and 24 weeks, as follows:

$$AWG = \frac{BWT - 670}{GA - 24}$$

The signed informed consent was acquired for each participant to be included in our study. The study protocol was approved by the Medical and Health Research Ethics Committee of the Faculty of Medicine, Public Health and Nursing Universitas Gadjah Mada/Dr. Sardjito General Hospital, Yogyakarta (Ref No: KE/FK/0410/EC/2019).

Analytical statistics

For the statistical analysis, we performed a descriptive analysis of the data. The continuous data were presented in mean and standard deviation (SD) or median and interquartile range (IQR) depending on the results of the normality test of the data using the Shapiro-Wilk or Kolmogorov-Smirnov test. The categorical data were presented in percentages. The comparison between the two groups was performed using student t-test or Mann-Whitney and Chi-square or Fisher Exact tests according to the type of the data. In this comparison analysis, we decided to use a cut-off for the AWG using a study from Uehara *et al.*[19] with a median value of 153.8g/wk. This was due to the Japanese population's characteristics, which are almost similar to the Indonesian population. A multivariable logistic regression analysis was conducted to assess the independent association among covariables. A value of $p<0.05$ was considered to be statistically significant.

RESULTS

A total of 50 mothers were included in this pilot study. The median age at the first registry was 20 ± 2.3 yo (median ± IQR). The majority of the women in this study with as many as 46 participants (92%) were aged >18yo, and only 4 participants were aged below 18yo.

TABLE 1. Baseline characteristics of study population at first registry

Characteristics	Total (n = 50)	<153.8g/wk (n = 10)	≥153.8g/wk (n = 40)	p
Demographic characteristics				
• Age at first registered (mean±SD yo)	20.7 ± 2.3	21.4 ± 2.4	20.6 ± 2.3	0.36
• Body weight (median±IQR kg)	57.0 ± 18.3	50.5 ± 21.9	57.0 ± 17.5	0.47
• Body height (median±SD cm)	154.0 ± 6.0	152.5 ± 11.3	154.0 ± 6.8	0.14
Gestational age at first registered (median±IQR wk)	30.5 ± 5.0	29.5 ± 5.0	31.0 ± 4.0	0.91
MUAC (mean±SD cm)	24.9 ± 3.37	24.7 ± 5.3	25.0 ± 3.34	0.90
Energy intakes/day (median±IQR kcal)	1775.9 ± 969	1656.2 ± 839	1775.9 ± 1161	0.32
Parity [n (%)]				
• Null	40 (80)	8 (80)	32 (80)	0.65
• ≥ 1	10 (20)	2 (20)	8 (20)	
Education background [n (%)]				
• Less than high school	16 (32)	5 (50)	11 (27.5)	0.17
• High school	34 (68)	5 (50)	29 (72.5)	

*p value < 0.05; MUAC: middle upper arm circumference; IQR: interquartile range; SD: standard deviation

In TABLE 1, we grouped the study population into two categories based on the cut-off value of AWG <153.8g/wk and ≥153.8g/wk. The median body weight of the subjects was 154.0 ± 18.3kg. Most subjects were recruited at a gestational age of 30.5 ± 5.0wk and there was no significant statistical difference between the groups (p=0.91). Most of the women had finished high school with as many as 68% while 32% had not finished high school.

The mean MUAC was 24.9±3.37cm among all subjects and there was also no significant difference between both groups (p=0.91). Overall, only 26% of all pregnant women in this study were found to have a MUAC <23.0cm. The mean birth weight was 3,086.6g, mean birth length was 48.5cm, with 80% nulliparas. Measurement of total energy intakes/day in our study was also performed using SQ-FFQ. Our study found that the median of total energy intake/day was 1,775.9 ± 969kcal. There was also a statistically insignificant association between total energy intake/day with average AWG in our study (p>0.05).

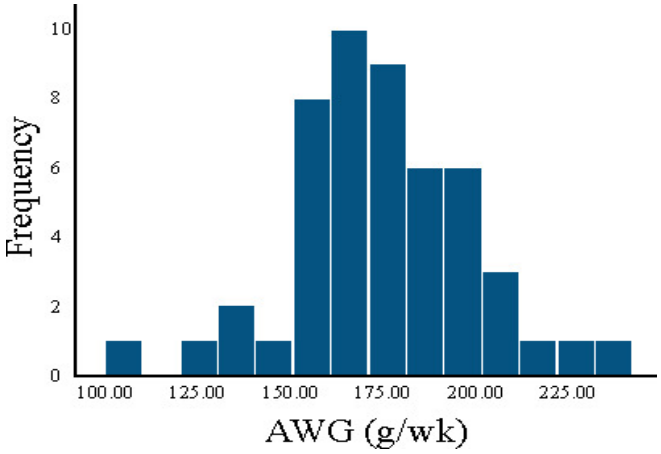

FIGURE 1. Histogram of the AWG showing its approximate normal distribution.

The AWG was normally distributed with a mean of 172.6g/wk (FIGURE 1). Authors categorized AWG using the previous cut-off value suggested by Uehara *et al.*with a median of six scans in each pregnancy. The average fetal growth rate was retrospectively calculated for the last 6 weeks to birth, and expressed as daily weight gain in grams per day. Adverse pregnancy outcome was defined as operative delivery for fetal distress, acidotic umbilical artery pH (< 7.15[19] Our study found that the mean of the AWG in our population was higher than the Japanese population with 172.6g/wk vs 153.8g/wk. However, in the univariate analysis, there were no associations found between higher MUAC and higher average fetal weight gain achieved (OR=1.03; 95% CI: 0.83-1.27; p=0.77) and energy intakes per day with AWG (OR= 1.0; 95% CI: 1.00-1.001; p=0.21). Socioeconomic factors such as the mother's educational background also showed no significant association with AWG (OR=0.38; 95% CI: 0.92-1.57; p=0.18).

DISCUSSION

In our population, we found a mean fetal weight gain of 172.6g/wk. This result was relatively higher than previous studies conducted by De Jong *et al.*[21] which found an average fetal weight gain of only 169.4g/wk using the Amsterdam population and Japanese population with a median value of the AWG was 153.8g/wk.[19]with a median of six scans in each pregnancy. The average fetal growth rate was retrospectively calculated for the last 6 weeks to birth, and expressed as daily weight gain in grams per day. Adverse pregnancy outcome was defined as operative delivery for fetal distress, acidotic umbilical artery pH (< 7.15 This previous study by De Jong *et al.*,[21] used a small sample of 200 high-risk pregnancies, and our study used only 50 participants with low-risk pregnancies. Several high-risk pregnancy-related conditions included in the study were a) previous history of IUGR; b) pregnancy-induced hypertension; c) pre-existing hypertension; d) smoked 15 or more cigarettes/day' and e) aged 35 yo or older. The above mentioned risk factors were significantly associated with adverse perinatal outcomes including LBW and stillbirths.[22,23]

Our finding of the AWG is still in the normal range as described earlier by Uehara *et al.*,[19] in the Japanese population (133 to 175.7g/wk). Our result was higher compared to the Japanese data, which is probably due to there was an increasing trend of prevalence of pre-pregnancy underweight mothers and poor weight gain during pregnancy which was correlated with an increased incidence of LBW infants in Japan (~9.4%) compared to the average of Organization for Economic Cooperation and Development (OECD) countries.[24] In our study, the authors also did not find any participants with an adverse neonatal outcome such as LBW.

Several factors which are thought to be associated with the occurrence of LBW such as maternal age, MUAC, and mother's educational background were not found in this study. It was possibly due to the relatively small sample size and also this study did not encompass low birth weight samples. In contrast to our study, Rahfiludin and Dharmawan in 2018Temanggung, Central Java, Indonesia. The sample size required for this study was 69 based on the Slovin formula. Data were collected using questionnaires and semi-quantitative Food Frequency Questionnaire forms. Data on infant birth weight was taken from midwives' delivery cohort records. Mid upper arm circumference (MUAC found that MUAC and mother's age were significantly associated with LBW.[8] The usefulness of MUAC for screening women at high risk of poor pregnancy outcomes is promising. Since MUAC reflects the

maternal fat composition and/or lean tissue stores, while the relationship between MUAC, BW and gestational age is independent.[25]

Remarkably, the authors found that the average energy intake/day of pregnant women in our study population was still below the WHO recommendation on energy requirement during pregnancy, which is approximately 2,140 kcal/d.[26] There was a deficit of as much as 370kcal/d according to our study. This problem should be confirmed with a larger-scale study.

CONCLUSION

In conclusion, our study showed that there is no association between maternal variables such as MUAC, mother's age, energy intake, and educational background with the average fetal weight gain achieved. Our study also found that the average energy intake/d of pregnant women in the study population is below the WHO guidelines.

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REFERENCES

1. Bianchi ME, Restrepo JM. Low birth weight as a risk factor for non-communicable diseases in adults. Front Med 2022; 8:793990. https://doi.org/10.3389/fmed.2021.793990
2. Knop MR, Geng TT, Gorny AW, Ding R, Li C, Ley SH, *et al*. Birth weight and risk of type 2 diabetes mellitus, cardiovascular disease, and hypertension in adults: a meta-analysis of 7 646 267 participants from 135 studies. J Am Heart Assoc 2018; 7(23):e008870. https://doi.org/10.1161/JAHA.118.008870
3. Belbasis L, Savvidou MD, Kanu C, Evangelou E, Tzoulaki I. Birth weight in relation to health and disease in later life: an umbrella review of systematic reviews and meta-analyses. BMC Med 2016; 14(1):147. http://doi.org/10.1186/s12916-016-0692-5
4. Aryastami NK, Shankar A, Kusumawardani N, Besral B, Jahari AB, Achadi E. Low birth weight was the most dominant predictor associated with stunting among children aged 12-23 months in Indonesia. BMC Nutr 2017; 3(1):16. https://doi.org/10.1186/s40795-017-0130-x
5. Islam MM. The effects of low birth weight on school performance and behavioral outcomes of elementary school children in Oman. Oman Med J 2015; 30(4):241-51. https://doi.org/10.5001/omj.2015.50
6. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, *et al*. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal 2019; 7(7):e849-60. http://doi.org/10.1016/S2214-109X(18)30565-5
7. Badan Penelitian dan Pengembangan Kesehatan. Hasil Riset Kesehatan Dasar (Riskesdas) 2018. Jakarta: Kementerian Kesehatan RI, 2018.
8. Rahfiludin MZ, Dharmawan Y. Risk factors associated with low birth weight. Kesmas 2018; 13(2):75-80. https://doi.org/10.21109/kesmas.v13i2.1719
9. Anil KC, Basel PL, Singh S. Low birth weight and its associated risk factors: Health facility-based case-control study. PLoS ONE 2020; 15(6):e0234907. https://dx.doi.org/10.1371/journal.pone.0234907
10. Falcão IR, Ribeiro-Silva RDC, De Almeida MF, Fiaccone RL, Rocha ADS, Ortelan N, *et al*. Factors

associated with low birth weight at term: a population-based linkage study of the 100 million Brazilian cohort. BMC Pregnancy Childbirth 2020; 20(1):536. https://doi.org/10.1186/s12884-020-03226-x
11. Abubakari A, Kynast-Wolf G, Jahn A. Maternal determinants of birth weight in Northern Ghana. PLoS One. 2015; 10(8):e0135641. https://doi.org/10.1371/journal.pone.0135641
12. Mongelli M, Benzie R, Condous G. Average fetal weekly weight gain: a novel measure of fetal growth velocity. J Matern Neonatal Med 2016; 29(4):676-9. https://doi.org/10.3109/14767058.2015.1015981
13. Ikenoue S, Miyakoshi K, Kasuga Y, Ochiai D, Matsumoto T, Tanaka M. Impaired fetal growth in mothers with inadequate gestational weight gain: a retrospective study in Japanese uncomplicated pregnancy. J Matern Neonatal Med 2020; 33(13):2227-31. https://doi.org/10.1080/14767058.2018.1545835
14. Bhavadharini B, Anjana RM, Deepa M, Jayashree G, Nrutya S, Shobana M, *et al*. Gestational weight gain and pregnancy outcomes in relation to body mass index in Asian Indian women. Indian J Endocrinol Metab 2017; 21(4):588-93. https://doi.org/10.4103/ijem.IJEM_557_16
15. Williams M, Turner S, Butler E, Gardosi J. Fetal growth surveillance: current guidelines, practices and challenges. Ultrasound 2018; 26(2):69-79. https://doi.org/10.1177/1742271X18760657
16. O'Connor D. Saving babies' lives: a care bundle for reducing stillbirth [Internet]. London; 2016. 1-30. https://www.england.nhs.uk/wp-content/uploads/2016/03/saving-babies-lives-car-bundl.pdf
17. Royal College of Obstetricians & Gynaecologists. The investigation and management of the small for gestational age fetus [Internet]. London; 2014. Report No.: Green-to Guideline No. 31. Available from: https://www.rcog.org.uk/media/t3lmjhnl/gtg_31.pdf
18. Grantz KL, Kim S, Grobman WA, Newman R, Owen J, Skupski D, *et al*. Fetal growth velocity: the NICHD fetal growth studies. Am J Obstet Gynecol 2018; 219(3):285.e1-285.e36. https://doi.org/10.1016/j.ajog.2018.05.016
19. Uehara R, Miura F, Itabashi K, Fujimura M, Nakamura Y. Distribution of birth weight for gestational age in Japanese infants delivered by cesarean section. J Epidemiol 2011; 21(3):217-22. https://doi.org/10.2188/jea.JE20100123
20. Ohuma EO, Villar J, Feng Y, Xiao L, Salomon L, Barros FC, *et al*. Fetal growth velocity standards from the Fetal Growth Longitudinal Study of the INTERGROWTH-21st Project. Am J Obstet Gynecol 2021; 224(2):208.e1-208.e18. https://doi.org/10.1016/j.ajog.2020.07.054
21. de Jong CL, Francis A, van Geijn HP, Gardosi J. Fetal growth rate and adverse perinatal events. Ultrasound Obstet Gynecol 1999; 13(2):86-9. https://doi.org/10.1046/j.1469-0705.1999.13020086.x
22. Chappell LC, Enye S, Seed P, Briley AL, Poston L, Shennan AH. Adverse perinatal outcomes and risk factors for preeclampsia in women with chronic hypertension. Hypertension 2008; 51(4):1002-9. https://doi.org/10.1161/HYPERTENSIONAHA.107.107565
23. Ota E, Ganchimeg T, Morisaki N, Vogel JP, Pileggi C, Ortiz-Panozo E, *et al*. Risk factors and adverse perinatal outcomes among term and preterm infants born small-for-gestational-age: secondary analyses of the WHO

multi-country survey on maternal and newborn health. PLoS One 2014; 9(8):e105155. https://doi.org/10.1371/journal.pone.0105155
24. Nomura K, Nagashima K, Suzuki S, Itoh H. Application of Japanese guidelines for gestational weight gain to multiple pregnancy outcomes and its optimal range in 101,336 Japanese women. Sci Rep 2019; 9(1):17310. https://doi.org/10.1038/s41598-019-53809-8
25. Ricalde AE, Velásquez-Meléndez G, Tanaka AC, de Siqueira AA. Mid-upper arm circumference in pregnant women and its relation to birth weight. Rev Saude Publica. 1998; 32(2):112-7. https://doi.org/10.1590/s0034-89101998000200002
26. Williamson CS. Nutrition in pregnancy. Nutr Bull 2006; 31(1):28-59. https://doi.org/10.1111/j.1467-3010.2006.00541.x