CORRELATION BETWEEN BIRTHWEIGHT AND BODYWEIGHT INCREASE OF PREGNANT WOMEN WITH NORMAL BODY MASS

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ABSTRACT

The objectives of this study were to find the characteristics of pregnant women and their newborn babies and correlation between birthweight and bodyweight of the pregnant women with normal body mass index (BMI). This study was carried out prospectively (longitudinal) to 55 pregnant women with normal body mass index in three locations: Dr Soetomo Hospital, Tambakrejo Community Health Center, and Maternity House "Sugiharti" Surabaya. BMI was measured at the first visit during the first trimester. All pregnant women were followed through natural pregnancy, and the bodyweight of the mother as well as the newborns were measured, and analyzed using multiple regression analysis. All newborns were delivered spontaneously, rear head first, in each location of study. The average birthweight was 3157.46 grams, no neonates was born with low birthweight. The increase of pregnant women's bodyweight was averagely 10.61 kg, and the lowest was 5.10 kg. In conclusion, there is correlation between birthweight and the increase of pregnant women bodyweight with normal BMI, according to cubic and quadratic model (p = 0.017 and p = 0.029). However, there was no significant correlation according to linear method (p = 0.086) from those variables.

Keywords: birthweight, bodyweight increase, body mass index

INTRODUCTION

In several developing countries, including Indonesia, the problem of nutrition remains a primary public health problem and it is an important indirect cause of mother and child death, a problem that should have been prevented. High maternal mortality rate (MMR) and neonatal mortality rate, as well as low birthweight (LBW), also depend on nutritional status of the pregnant women. Pregnant women with poor or sub-optimal nutritional status tend to give birth to newborns with low bodyweight and with higher expectation of death compared to those given birth by mothers with normal bodyweight (Marsianto et al. 1997). Until recently, neonatal death is predominated by low birthweight infants. In Surabaya, Rochjati et al. reported that in two years (1984-1985) 18.12% of neonates born in Dr Soetomo Hospital had low birthweight. Low birthweight infants have a death risk 17 times higher than those born in normal birthweight. In Tanjungsari Usman A et al. reported that in five years (1976-1980), in Dr Soetomo Hospital 69.96% of infant's death during neonatal period comprised those with low birthweight.

To overcome the problem, health and nutritional status monitoring of pregnant women, either at the early or during pregnancy, are potential approaches in relations to the improvement of mother and child welfare. Birth bodyweight has positive correlation with the increase of mother's bodyweight during pregnancy. It is possible that the higher the increase of mother's bodyweight, the higher the bodyweight of the newborn. By reliable monitoring of pregnant women's nutritional status, the opportunity to give birth to a healthy and safe newborn will be higher, who can be expected to grow and develop as qualified human resource. Gopalan suggested that in determining the nutritional condition, the data on clinical signs and biochemical examination should be collected quantitatively. Anthropometric examination is suggested more, as it is more practical, accurate, and easy to be practiced by anyone after receiving simple training. The anthropometric examination should be carefully undertaken to obtain high accuracy, so that it can be used as an alert of the presence of newborn with low bodyweight, and it can also be used as the reason of early referral for pregnant women.

From the results of studies on nutrition ever reported in Indonesia, there are no standard criteria in subject selection and the design of study. The feasible designs
are cross-sectional and longitudinal studies. To obtain reference standard, longitudinal studies is more possible, yet it needs more costs and lengthy time. Marsianto et al. (1992) had conducted a retrospective study in Dr Soetomo Hospital, and concluded that there was correlation between nutritional status of pregnant women and birthweight. Nutritional status of pregnant women and birthweight is based on pregnant women's Road to Health Card (Kartu Menuju Sehat, KMS). Pregnant women with lower nutritional status had a risk of giving birth to low birthweight infants 2.38 times higher than pregnant women with satisfactory nutritional status.

This study was carried out since there has been no previous study on the correlation of birthweight and total increase of pregnant women's bodyweight whose body mass index (BMI) is normal (ideal weight) and measured at the first visit during trimester I. The increase of neonatal deaths due to the high incidence of low birthweight should have been prevented by the monitoring of nutritional status of pregnant women. The objective of this study was to find correlation between birthweight and bodyweight increase of pregnant women with normal BMI and to find the characteristics of pregnant women and their newborns (BMI: 18.5-25.0 kg/m²). The benefits of this study are that at the first visit (trimester I) provides easiness for health provider to obtain information in order to have optimum increase of body weight, particularly in pregnant women with normal BMI. At the last visit (before delivery) it will provide information in estimating birth bodyweight.

MATERIALS AND METHODS

This was a prospective (longitudinal) study by following the pregnant mothers from trimester I (positive pregnancy test) until about or at the time of delivery. Only mothers included in inclusion criteria were involved as subjects in this study. The study was performed in three locations, Dr Soetomo Hospital, Community Health Center Tambakrejo, and Maternity House "Sugiharti", all in Surabaya, with the period of study was about 12 months. The inclusion criteria were low risk pregnant women; high risk pregnant women, with the risk factors other than those suspected to have effects on fetal growth (such as diabetes mellitus, hypertension, heart disease, renal disease, pulmonary disease/tuberculosis, hepatitis, malaria, typhoid, malignancy, multiple pregnancy, congenital abnormalities, severe anemia, and pregnant women with the habits of cigarette smoking, alcoholism, and drug dependence) (Lin 1984; Marsianto et al. 1997); pregnant women who at the time of first antenatal visit had pregnancy age equal to or less than 12 weeks and had normal BMI between 18.5 and 25.0 kg/m²; pregnant women who carried out antenatal care at least 4 times, pregnancy age of 38 - 42 weeks, minimal education level of elementary school (equal to or less than 6 years), recalling the last day of menstruation with regular menstrual history prior to the pregnancy, and willing to deliver at respective location or in Dr Soetomo Hospital if referred. The exclusion criterion was pregnant women with body height equal to or less than 145 cm. The withdrawal criteria were pregnant women who stated their desire to withdraw and those who experienced complications during the study.

Previous studies by Enoch and Kamarwati (1992) and by Marsianto et al. found positive correlation between pregnant mother's nutritional status (measured based on the increase of mother's bodyweight during pregnancy) and newborns' bodyweight at three community health centers in Cirebon (r = 0.59, p < 0.05), while Barbara F Abrams et al. (1986), who performed a study using regression analysis, which is similar to that we performed here, found highly significant correlation between birthweight and the increase of pregnant women's bodyweight. After excluding several factors affecting the growth of the fetus, samples involved in this study were 29 individuals. This was an observational study. All subjects developed naturally without intervention of nutritional supplementation. Since all subjects had started with good nutritional status (ideal bodyweight), all subjects were regarded to have the same nutritional needs, either vitamin, calorie, or mineral. This reason was used to deny the possibility of confounding variables. Data analysis was carried out using (multiple) regression, i.e., linear and non-linear regression.

RESULTS

From 105 samples in this study, only 55 could be processed, 44 were excluded, 41 withdrew, gave birth to a baby, or delivered in other place, while other three samples in Dr Soetomo Hospital had pregnancy complications, i.e., abortus (1 sample), hyperemesis (1 sample), and severe preeclampsia (1 sample). Sample size not included in inclusion criteria were 6 samples, 4 due to age of pregnancy of less than 38 weeks, 1 due to intrauterine fetal death with unknown causes, and 1 due to antenatal care of less than four times. Most of the samples were from centers other than Dr Soetomo Hospital, i.e., from Tambakrejo health center and Maternity House "Sugiharti", where the sample size in both places were the same, 20 persons (36.36%) Most of the pregnant women observed aged 20-24 years (43.64%), 5 (9.09%) of pregnant women aged less than 20 years and only 1 (1.82%) of them aged equal to or
more than 35 years. Most of pregnant women, comprising 27 persons (49.09%) had formal education of senior high school. Those with elementary education were only 7 persons (12.73%), and those with higher education were 6 (10.91%). Most of them were household mothers, comprising 35 persons (63.64%), only 2 were civil employees (3.64%). Thirty of them (54.54%) were primigravidas, while only 1 had the fourth pregnancy (1.82%), and none the fifth or more pregnancy. Nineteen (34.55%) of those women had pregnancy interval from oldest to youngest child between 2 and 9 years. Six (10.91%) had an interval of less than 2 years and none more than 10 years. None of them made their first antenatal visit in pregnancy age of 0-4 weeks. Most of them, 36 persons (65.45%), had pregnancy age of 9-12 weeks at the first antenatal visit. A majority of 41 persons (74.54%) had antenatal care 4-8 times of visit. Pregnancy age during delivery had no significant difference in those four groups. Forty and forty-one is the most common pregnancy age when the delivery occurred, which was found in 15 (27.27%) pregnant women. All of those women gave birth in respective locations where this study was conducted. None of them studied at Tambakrejo health center and Maternity House "Sugiharti" should have delivered in Dr Soetomo Hospital due to referral.

Table 1. The distribution of pregnant women according to the average, minimum, and maximum anthropometric values

<table>
<thead>
<tr>
<th>Anthropometry</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodyweight at the first antenatal (kg)</td>
<td>49.44</td>
<td>5.26</td>
<td>41.50</td>
<td>67.00</td>
</tr>
<tr>
<td>Bodyweight at the first antenatal (cm)</td>
<td>152.75</td>
<td>4.34</td>
<td>146.00</td>
<td>164.00</td>
</tr>
<tr>
<td>Body Mass Index/ BMI (kg/m²)</td>
<td>21.16</td>
<td>1.88</td>
<td>18.69</td>
<td>25.00</td>
</tr>
</tbody>
</table>

At the first antenatal care, those mothers had average body weight of 49.44 kg, minimum bodyweight of 41.50 kg and maximum 67.00 kg, while the average body height was 152.75 cm, shortest 146.00 cm and tallest 164.00 cm. In addition, pregnant women in trimester I or at the time of the first antenatal visit had average Body Mass Index (BMI) of 21.16 kg/m², the lowest 18.69 kg/m² and the highest 25.0 kg/m². In this study, total increase of body weight among pregnant women was averagely 10.61, minimum increase of bodyweight was 5.10 kg and maximum was 21.00 kg.

More than a half of the newborns, 29 (52.73%) infants, had birthweight between 3000 and 3499 grams. Only 1 (1.82%) of newborns had birthweight equal to or more than 4000 grams, and none of them had birthweight less than 2500 grams. Most of the babies, comprising 29 (52.73%) infants, were male, while 26 (47.27%) were female. All were born spontaneously, rear head first.

Table 2. Characteristics of pregnant women according to average, minimum, and maximum increase of bodyweight

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodyweight increase (kg)</td>
<td>10.61</td>
<td>2.90</td>
<td>5.10</td>
<td>21.00</td>
</tr>
</tbody>
</table>

Table 3. Distribution of pregnant women according to their infants' birthweight

<table>
<thead>
<tr>
<th>Birthweight</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2500 grams</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2500 – 2999 grams</td>
<td>15</td>
<td>27.27</td>
</tr>
<tr>
<td>3000 – 3499 grams</td>
<td>29</td>
<td>52.73</td>
</tr>
<tr>
<td>3500 – 3999 grams</td>
<td>10</td>
<td>18.18</td>
</tr>
<tr>
<td>&gt; or equal to 4000</td>
<td>1</td>
<td>1.82</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4. Infants characteristics according to average, minimum, and maximum anthropometric values

<table>
<thead>
<tr>
<th>Anthropometry</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birthweight (gram)</td>
<td>3157.46</td>
<td>49.76</td>
<td>2500</td>
<td>4400</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>49.76</td>
<td>1.73</td>
<td>46.00</td>
<td>58.00</td>
</tr>
</tbody>
</table>

The newborns had an average birthweight of 3157.46 grams, the lowest birthweight was 2500 gram, and the highest was 4400 grams. The length of the infants was averagely 49.76 cm, the shortest was 46.00 cm and the longest 58.00 cm. In this study, all data were analyzed using regression technique to obtain a curve or a model of the correlation between bodyweight increase of pregnant women (x) with normal BMI and birthweight (y). The regression analysis was applied to five popularly used pattern/model of regression analysis. In this study, the significance level was 0.05 (5%) and the correlation was regarded as fit if the p value was less than 0.05. The variables had significant correlation if one or more of several models of regression analysis had significance value of 0.05. From the results of analysis applied in these five regression models, the significance level was p = 0.017 according to cubic model and p = 0.029 according to quadratic model. It can therefore be inferred that there was correlation between birthweight and the increase of bodyweight of mothers with normal BMI. Correlation between the variables can be seen in Figure 1.
DISCUSSION

Nutritional status before and after pregnancy is an important factor in determining birth bodyweight. A woman with satisfactory nutritional status before and after pregnancy, even since childhood, has higher probability to give birth to healthy infants without complications as compared to women with poor nutritional condition (Ahmad 1995; King et al. 1990). This finding is in line with the finding of this study, where all pregnant mothers had normal BMI (ideal weight) or good nutritional status, and none of them gave birth to infants with low birthweight or birthweight of less than 2500 grams.

BMI is one of anthropometric examinations that can be used in determining adult female nutritional status, but it cannot be applied or measured in pregnant women (Dept. of Health 1994). In similar previous studies BMI was always used in mothers before they were pregnant. The information was obtained through interview during their first antenatal visit. This can hardly be applied in Indonesia, since the mothers have higher subjectivity level. Another reason is that they forget or even have no idea about their bodyweight before pregnancy. Additionally, there has been no habit to consult or to have health examination before marriage or pregnancy. This study, however, attempted to use the BMI as a means to determine nutritional status of pregnant mothers, with a note that the BMI was measured at trimester I. Reasons to measure BMI at trimester I are as follows: trimester I is the adjustment period of the mothers to their pregnancy. The progress of fetal growth remains low and nutritional need also remains less abundant. It is suggested that nutritional need of pregnant women in trimester I is similar to that of unpregnant women. Additionally, in trimester I the bodyweight has not increased significantly, in which total increase of is only about 0.7 - 1 kg. Moreover, bodyweight reduction can also occurs due to the loss of appetite, nausea and vomiting resulting from the effect of hormonal or emotional changes. Bodyweight increase, therefore, is still unstable or in fluctuation (Pemoll 1991; Suitor 1994).

Extrem age of the mothers is usually correlated with increased poor perinatal final outcome, such as stillbirth, perinatal death, low birthweight, retarded fetal growth, premature birth and congenital abnormalities. However, there has been no agreement on the limit of age in correlation with the increase of risk. Some authors use the limit of less than 15 years and more than 35 years, and the others use less than 20 years and more than 40 years, since elderly age is associated with biological changes related to degenerative diseases (Marsianto et al. 1997). Although there has been no definite
agreement, this study used the limit of mother's age of more than 18 years, since one of the requirements of BMI measurement is that it should be applied to adults, not to adolescence, while it has been suggested that adolescent pregnancy is commonly related to delayed fetal growth as the adolescents themselves remain at growth period, during which a lot of nutrition is needed (Dept. of Health 1994; Marsianto et al. 1997).

A study by Enoch and Kamarwati, as well as by Marsianto et al., showed that there was no significant correlation between the length of education and mother's nutritional status. Suntoro et al. in their study on the effect of nutritional status in pregnant women on low birthweight found that mother's education had no effect on their nutritional status during pregnancy (Marsianto et al. 1997). This study used the lowest level of education of 6 years or elementary school and antenatal visit at least 4 times, with the hope that we could provide motivation, suggestions on health care and nutrition, as well as to have regular pregnancy examination. These steps could provide significant contribution to improve the health of the mothers themselves.

Rochjati P. found correlation between parity and the incidence rate of LBW. At the first parity, the rate is the highest, and then it declines between parity two and five, and subsequently it increases again. It is possible that parity also has correlation with nutritional status of pregnant woman (Marsianto et al. 1997). However, this study conversely revealed that most of the mothers (54.54%) were primigravidas, 21.82% were their second and third pregnancy, and 1.82% were their fourth pregnancy. All mothers started with good nutritional status (normal body mass index). It was apparent that none of the mothers gave birth to infants with low birthweight or less than 2500 grams. Previous retrospective study by Marsianto et al. (1992) in Dr Soetomo Hospital, Surabaya, revealed correlation between pregnant women's nutritional status and birthweight based on their Road to Health Card (KMS), but it had not proved the presence of correlation between BMI-based nutritional status and birthweight. Additionally, the amount of bodyweight increase for pregnant woman with normal BMI (particularly for Indonesians) in order to have optimum birthweight has not been known (Ahmad 1995; Marsianto et al. 1997). This preliminary study would provide the information needed.

In this study, none of the infants had birthweight of less than 2500 grams. The average birthweight was 3157.46 grams (SD 377.57 grams), minimum birthweight was 2500 grams and maximum 4400 grams. The average increase of bodyweight was 10.61 kg (SD 2.90 kg), the minimum was 5.10 kg and the maximum was 21.0 kg. It can therefore be inferred that to obtain optimum birthweight, a pregnant mother with normal BMI (bodyweight) needs an average bodyweight increase of 10.61 kg or minimally 5.10 kg during the trimester I. Hytten found that total bodyweight increase in healthy primigravidas without reducing total dietary intake was about 12.5 kg (Pemoll 1991). The American College of Obstetrician and Gynecologist suggests an increase of 10-12 kg bodyweight during pregnancy (Marsianto et al. 1997), while in Indonesia (Bogor) the normal bodyweight increase during pregnancy is about 9 kg (Winardi 1990). In comparison, it is apparent that bodyweight increase in this study is not significantly different from those found in the study by Hytten, the recommendation from The American College of Obstetrician, as well as the study in Bogor.

One literature writes that the acceptable average increase of bodyweight during pregnancy is 12.5 kg. The accumulation of bodyweight increase in trimester I was 12.5 kg. In trimester II and III the average increase of bodyweight is about 0.3 kg/weeks and 0.3-0.5 kg/weeks (Maria et al. 1994). Brown et al (1986) had conducted a study on 459 pregnant women with lower income and gave birth to infants with birthweight of 3000 - 4500 grams, the average increase of bodyweight was 0.22 kg/weeks in trimester I, 0.52 kg/weeks in trimester II, and 0.4 kg/weeks in trimester III. In this study, due to technical problems we could not inform the weekly increase of bodyweight in each trimester. Therefore, further studies with more accurate observation on the increase in each trimester should be undertaken to obtain the information. Kramer wrote that mothers with bodyweight of less than 54 kg relatively had a risk of low birthweight (King et al. 1990). Although the information above cannot be compared with this study, the results of this study at least provide a profile that pregnant woman with minimal bodyweight of 41.50 kg in trimester I is able to give birth to infant with optimum birthweight (non LBW).

To find the correlation between variables in this study, not only we used regression analysis and linear model, but also applied the five regression models that were commonly used in search for the significance level of $p < 0.05$ from one of the models. We found that there was correlation between birthweight and the increase of bodyweight of mothers with normal BMI, in cubic model ($y = 1487.59 + 479.x - 44.66.x^2 + 1.34.x^3$, $p = 0.017$) or in quadratic model ($y = 3776.83 - 141.45.x + 7.30.x^2$, $p = 0.029$). However, the significant correlation was not found according to linear model ($p = 0.086$). By this finding, it can be inferred there is correlation between birthweight and the increase of bodyweight of pregnant mothers with normal BMI. The correlation
between variables is not necessarily linear. The result of this study was different from that of The National Academy of Sciences (1990) in the United States, which found correlation between variables in linear model among pregnant mothers with different nutritional status, the lean, ideal, fat, and obese ones.

Interestingly, in this study there were five samples with normal BMI who were dropped out from the study since they had body height equal to or less than 145 cm and followed continuously during their pregnancy until delivery. The use of 145 cm as the minimum body height is based on the theory that short mothers symmetrically will give birth to low birthweight infants compared to tall mothers (Seidman 1992). In fact, this theory did not fit with the pregnancy outcome of the five dropped-out patients. These five samples were able to give birth to infants with normal bodyweight as seen in the following table.

Table 5 shows that the shortest mother (BH = 137 cm) has the highest BMI compared to other four samples. However, to obtain normal birthweight (2650 grams), the shortest mother needed higher increase of bodyweight compared to the other mothers. This is different from the tallest mother (BH = 145 cm) with BMI 23.78 kg/m². This mother only needed a bodyweight increase of 5.50 to give birth to an infant of 3400 grams. After these samples were reentered, and the analysis was repeated, the latter conclusion was not different from the previous one, in which there was correlation between birthweight and the increase of bodyweight of mothers with normal BMI in cubic model ($y = 2158.40 + 312.848.x - 32,153.x^2 + 1.0516.x^3$, $p = 0.018$) and quadratic model ($y = 3849.07 - 156.80.x + 7.9241.x^2$, $p = 0.019$), while there was no significant correlation in linear model ($p = 0.125$).

In the curve, it is apparent that most of the samples are clustered in the middle. Could the correlation between birthweight and bodyweight increase be caused by the presence of 1 sample who gave birth to an infant with birthweight of 4400 grams? After the sample was excluded and multiple regression analysis was carried out again, the result showed that none of the analyses revealed significant correlation (Linear $p = 0.919$, logarithmic $p = 0.861$, quadratic $p = 0.670$, cubic $p = 0.475$, and exponential $p = 0.865$). This also leads to the conclusion that a pregnant mother with normal BMI (body weight) in trimester I will give birth to infant with optimum bodyweight as long as she can increase her bodyweight during pregnancy at least 5.10 kg. The birth of infant with 4400 grams in Sugiharti maternity house could be the outcome of diabetic case in pregnancy. Unfortunately, the laboratory examination of the mother's blood glucose was not carried out in antenatal examination, during the pregnancy, and after delivery. This is one of the shortcomings in this study. To prevent such problem, further studies should involve a better screening supported with laboratory examination.

**CONCLUSIONS**

All pregnant women with normal BMI in this study were able to give birth to infants with birthweight of more than 2500 grams, and average birthweight was 3157.46 grams. The average increase of bodyweight needed by a pregnant mother with normal BMI was 3157.46 grams. The average increase of bodyweight needed by pregnant woman with normal BMI in this study was 10.61 kg. The lowest bodyweight of pregnant mother with normal BMI in this study was 41.50 kg. There is correlation between birthweight and the increase of bodyweight of pregnant mothers with normal BMI. Pregnant mothers with normal BMI should increase their bodyweight of 10.61 kg to obtain normal birthweight. The result of this study provides information on the estimation of birthweight prior to the delivery by using mathematic equation and the parabolic picture. Further similar studies should observe pregnancy in each trimester and apply better sample screening, supported with laboratory examination. Studies on the correlation between birthweight and the increase of bodyweight in lean mothers (BMI < 18.5 kg/m²) by using nutritional intervention, either with education or nutritional supplementation, and also in fat mothers (BMI > 25.0 kg/m²), also by using nutritional intervention, with education or observation of the complications. Further studies on correlation between birthweight and the increase of bodyweight in pregnant mothers should also involve other anthropometric parameters, such as pre-pregnancy bodyweight, body height, upper arm circumference, etc.

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