ความสัมพันธ์ระหว่างทารกแรกเกิดตัวเล็กกับดัชนีมวลกายต่ำก่อนตั้งครรภ์
Relationship between Small for Gestational Age Newborns and Pre-pregnancy Low Body Mass Index

นิพนธ์ต้นฉบับ

Original Article

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วารสารไทยเภสัชศาสตร์และวิทยาการสุขภาพ2563;15(2):68-74.

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บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาความสัมพันธ์ระหว่างดัชนีมวลกายต่ำก่อนตั้งครรภ์ของมารดากับภาวะทารกแรกเกิดตัวเล็ก **วิธีการศึกษา:** เป็นการศึกษาแบบย้อนหลังระหว่างปีงบประมาณ พ.ศ. 2558 - 2560 (1 ตุลาคม 2557 - 30 กันยายน 2560) รวบรวมข้อมูลจากหญิงตั้งครรภ์เดี่ยวจำนวน 421 คนที่ฝากครรภ์และคลอดทารกน้ำหนักน้อยที่ศูนย์การแพทย์สมเด็จพระเทพรัตนราชสุดาฯ สยามบรมราชกุมารี ตัดสินภาวะทาแรกเกิดตัวเล็กโดยเกณฑ์ standard intrauterine growth curve of Thai neonates นำปัจจัยดัชนีมวลกายต่ำก่อนตั้งครรภ์ คุณลักษณะส่วนบุคคลอื่น ๆ ปัจจัยการตั้งครรภ์และฝากครรภ์มาพิจารณา ใช้สถิติการถดถอยโลจิสติค **ผลการศึกษา:** เมื่อควบคุมอิทธิพลของตัวแปรคุณลักษณะส่วนบุคคลของมารดา พบว่าตัวแปรที่สัมพันธ์กับโอกาสที่มารดาจะคลอดทารกแรกเกิดตัวเล็ก ได้แก่ ดัชนีมวลกายต่ำก่อนตั้งครรภ์ (OR = 2.392; 95% CI = 1.0677 – 5.3617) การฝากครรภ์ครั้งแรกช้า (OR = 2.149; 95% CI = 1.1568 – 3.9943) ภาวะแทรกซ้อนขณะตั้งครรภ์ (OR = 1.988; 95% CI = 1.0760 – 3. 6738) อายุครรภ์เมื่อคลอดน้อยกว่า 37 สัปดาห์ (OR = 50.191; 95% CI = 21.6794 – 116.1989) และการตั้งครรภ์ครั้งที่ 2 (OR = 0.404; 95% CI = 0.2063 – 0.7896) **สรุป:** ดัชนีมวลกายต่ำก่อนตั้งครรภ์ของมารดาสัมพันธ์อุบัติการณ์คลอดทารกตัวเล็ก ข้อค้นพบนี้ชี้ให้เห็นว่าการมีดัชนีมวลกายที่เหมาะสม ตลอดจนการติดตามน้ำหนักระหว่างตั้งครรภ์ อาจมีอิทธิพลต่อการลดโอกาสคลอดทารกตัวเล็กและช่วยเพิ่มน้ำหนักทารกได้

คำสำคัญ: ทารกแรกเกิดตัวเล็ก, ดัชนีมวลกายต่ำ, ก่อนตั้งครรภ์

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Abstract

Objective: To investigate the association between low maternal pre-pregnancy body mass index (BMI) and the incidence of small for gestational age (SGA) newborns. **Method:** In this retrospective study, data were collected from 421 women with singleton pregnancy who had antennal care (ANC) and delivered newborn with low birth weight in the HRH Princess Maha Chakri Sirindhorn Medical Center (MSMC) Hospital from October 1, 2014, to September 30, 2017. The individual socio-demographic and maternity records were reviewed. SGA status was classified using the standard intrauterine growth curve of Thai neonates. A logistic regression analysis was conducted. **Results:** After controlling for individual socio-demographic factors, women with BMI < 18.5 kg/m^2 (OR = 2.392; 95% CI = 1.0677 – 5.3617), late ANC registry (OR = 2.149; 95% CI = 1.1568 – 3.9943), obstetric complication (OR = 1.988; 95% CI = 1.0760 – 3.6738), gestational age at delivery < 37 week (OR = 50.191; 95% CI = 21.6794 – 116.1989) and the 2nd gravida (OR = 0.404; 95% CI = 0.2063 – 0.7896) were significantly associated with having SGA newborn. **Conclusion:** Low pre-pregnancy BMI was correlated SGA newborn. Appropriate maternal BMI at conception followed by adequate weight gain during pregnancy may help reduce the risk of SGA newborn and increase the birth weight.

Keywords: small gestational age, low body mass index, pre-pregnancy

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Introduction

Newborns who are small for gestational age (SGA) are those whose weight is less than their 10th percentile of their gestational age.[1] The infant weight at birth suitable for the their gestational age is one of the goals of maternal and fetal care. Obstetric care through out the first 270 days of gestation is critical for such good fetal health. Risks of intrauterine growth restriction (IUGR) could be chromosomal anomalies and placental defects leading to dysfunctional exchanges of nutrients, oxygen and waste between the mother's blood circulation and the fetus.[2,3] Such IUGR could result in an infant's weight at birth of less than 10th percentile of the gestational age. IUGR could be monitored by the regular monitoring and evaluation on the fetus using ultrasound. However, the interpretation of ultrasound needs knowledge and expertise of the healthcare providers. On the other hand, this IUGR could be more efficiently assessed with the newborn's size and weight.[4]

SGA newborns could face certain complications either during gestation, perinatal, and postpartum. In addition, SGA could have an increase in long-term health risks on the fetus including stillbirth, perinatal hypoxia, hypothermia, and abnormality in nervous system development, and in the long run the increased risk of chronic obstructive pulmonary disease (COPD), cardiovascular

complications, type 2 diabetes, reproductive system abnormality and kidney disease.[3,5-7]

The most contributing factors of SGA infants are environmental and maternal factors.[3,8,9] These include maternal age of either younger than 16 years or older than 35 years[3], mother living in rural area[10], access to healthcare[11], body mass index (BMI) before pregnancy, malnutrition, smoking and alcohol intake, infection during pregnancy such as German measles and sexually transmitted diseases.[6,12-14]

Regarding fetal growth monitoring, it is somewhat practically difficult to know the given fetus weight progresses to be appropriate for its gestational age. Preliminary screening on the mother's weight showed that the mother's weight before and during pregnancy is associated with the newborn's weight.[15-17] This finding supports the basis that how much weight the mother should gain throughout the whole pregnancy. In general, the mother should gain at least 7 but not more than 13 kilograms for the entire pregnancy period. If less than 9 kilograms of weight gain, the risk of SGA could be increased by 1.8 times of the mothers with proper weight gain of 9 to 12 kilograms.[5] With malnutrition, the mother could gain less weight and as a result, malnutrition for the fetus. Fetal malnutrition could lead to infant's problem of nervous system development[9] and the increased risk of stillbirth and infant death.[18]

The actual monitoring on the mother weight at every antenatal care (ANC) visit could be relatively late to assess the fetal size and health suitable for gestational age in a timely fashion. Therefore, to use the mother's weight before pregnancy and height to calculate body max index could be a direct method for the individual nutritional assessment without the need to know the mother's age. The result of this assessment method could guide appropriate nutritional care for individual mothers. Body mass index (BMI) could be used as an indicator of the mother's nutritional status. It could guide nutritional care proper for each gestational age and weight for each week. Based on the recommendation, mother with lower than normal BMI (< 19.8 kg/m^2), normal BMI (19.8 to 26.0 kg/m^2), higher than normal BMI (more than 26.0 to 29.0 kg/m^2), and extremely high BMI or obese (> 29.0 kg/m^2) should gain weight of 0.49, 0.44, 0.30, and 0.30 kg/week, respectively.[1] Throughout the pregnancy period, they also should gain a total weight of 12.7 – 18.2, 11.4 – 15.9, 7.0 – 11.5, and > 7 kilograms, respectively.[1] Studies showed that mothers with pre-pregnancy low BMI were more likely to have a higher risk of fetal growth retardation and newborn with low birth weight when compared with mothers with normal BMI (1.5[20] and 5.2[21] times, respectively).

At the antenatal clinic of the HRH Princess Maha Chakri Sirindhorn Medical Center (MSMC) Hospital, no data of newborn with low birth weight or pre-pregnancy weight of the mother have been available for ANC care till delivery. The plan to improve ANC care for both the mother and the newborn has been somewhat difficult. More understanding on the association of BMI of the pre-pregnancy mother and the low birth weight newborn has been needed. This study aimed to examine the association between low maternal pre-pregnancy BMI and the small for gestational age (SGA) newborns. This study was a part of the research project of incidence and trend of fetal growth retardation and its contributing factors.

Methods

This retrospective quantitative research collected data from the logbook of delivery cases at the labor room and electronic data base of ANC clinic of the HRH Princess Maha Chakri Sirindhorn Medical Center (MSMC) Hospital, Ongkharak, Nakhonnayok province. The study was approved by the hospital director on August 20, 2018 with the exemption from ethical consideration by the ethics committee for human research of Srinakharinwirot University for the research project 348/61X (October 11, 2018).

Study population was pregnant women registered at the ANC clinic and delivered at the labor room of the MSMC. Study sample was those women receiving such care in the fiscal year of 2015 to 2017 (October 1, 2014 to September 30, 2017). The sample of 576 women was selected by purposive sampling method. The inclusion criteria were the mother with singleton pregnancy delivering a live birth newborn of less than 2,500 gram of weight. Exclusion criteria were multifetal pregnancy (32 women), having ANC care at the MSMC but delivering the newborn at other setting (89 women), having ANC care at other setting but delivering the newborn at the MSMC (34 women). As a result, a total sample of 421 women were included.

Research instruments

In this retrospective study, data collection form consisted of two parts. The first part collected demographic data

including age, nationality, BMI (weight and height), healthcare payment insurance status, and smoking and alcohol intake during pregnancy. The second part collected history of pregnancy and ANC care including gestational age (trimester) at the ANC registry, number of ANC visits, continuity of ANC visits, gestational age at delivery, history of delivering newborn with low birth weight, history of having fetus with growth retardation, hematological test results, chronic illnesses before pregnancy, pregnancy complications, and the status of small for gestational age (SGA) newborn. Whether the newborn was SGA or not, is was classified by the criteria of the standard intrauterine growth curve of Thai neonates delivered at Rajavithi Hospital.[21]

Data analysis

All demographic and pregnancy related data were presented by descriptive statistics including frequency with percentage. The relationships between SGA newborn status and various demographic, pregnancy history, and ANC history variables were examined with chi-square test.

After bivariate analysis, if significant association between having having SGA newborns and BMI was found, logistic regression to further examine such risk controlled for other factors was conducted. Statistical significance level was set at a type I error or 5% (or *P*-value < 0.05). Statistical analysis was performed using STATA software.

Results

Of the total of 421 women, there were more women with SGA newborn (288 women or 68.41%). It was found that age, BMI, healthcare payment insurance status, smoking, and alcohol intake were not different between the newborns with and without SGA (Table 1). However, mothers with Thai nationality were more likely to have SGA newborns compared with other nationalities (*P*-value = 0.012).

In terms of pregnancy status, it was found that number of pregnancy and gestational age at delivery were different between women with and without SGA newborn (*P*-value = 0.37 and < 0.001, respectively) (Table 2). Other characteristics including gestational age at ANC registry, continuity of ANC visit, history of pre-term labor, history of fetal growth retardation, pregnancy complication and chronic illness before pregnancy were not different between women with and without SGA newborn.

Table 1 Characteristics of the mothers with and without small for gestational age (SGA) newborn.

Characteristics	Number (%) of the mother (N = 421)				*P*-value*
	SGA newborn (n = 288)		Non-SGA newborn (n = 133)		
Age (years)					
< 20	12	4.17	9	6.77	0.216
20 – 35	218	75.69	105	78.95	
> 35	58	20.14	19	14.29	
Nationality					
Thai	264	91.67	111	83.46	0.012
Others	24	8.33	22	16.54	
Body mass index (kg/m^2)					
Lower than normal (< 19.8)	72	25.00	22	16.54	0.229
Normal (19.8 to 26.0)	146	50.69	71	53.38	
Higher than normal (> 26.0 to 29.0)	39	13.54	21	15.79	
Obese (> 29)	31	10.76	19	14.29	
Healthcare payment scheme					
Out-of-pocket / no insurance	89	30.90	41	30.83	0.988
Having insurance	199	69.10	92	69.17	
Smoking					
Smoking	2	0.69	2	1.50	0.426
No smoking	286	99.31	131	98.50	
Alcohol intake					
Alcohol intake	5	99.31	3	1.19	0.169
No alcohol intake	286	0.69	130	99.31	

* Chi-square test.

Table 2 Pregnancy and ANC related characteristics of the mothers with and without small for gestational age (SGA) newborn.

Pregnancy and ANC related characteristics	Number (%) of the mother (N = 421)				*P*-value*
	SGA newborn (n = 288)		Non-SGA newborn (n = 133)		
Gestational age at ANC registration (weeks)					
1 - 12	141	48.96	68	51.13	0.878
> 12 to 28	118	40.97	51	38.35	
> 28	29	10.07	14	10.53	
Number of pregnancy					
1	146	50.69	56	42.11	0.037
2	72	25.00	48	36.09	
3	53	18.40	20	15.04	
4 - 5	14	4.86	4	3.01	
Continuity of ANC visit					
Perfect follow-ups	217	75.35	96	72.18	0.489
Imperfect follow-ups	71	24.65	37	27.82	
History of low birth weight newborn					
Had low birth weight newborn	1	0.35	1	0.75	0.575
Never had low birth weight newborn	287	99.65	132	99.25	
History of pre-term newborn delivery					
Had delivered pre-term newborn	3	1.04	2	1.50	0.684
Never had delivered pre-term newborn	285	98.96	131	98.50	
Hematologic status					
Both Hb and hct were normal	227	78.82	105	78.95	0.976
Either Hb or Hct was abnormal	61	21.18	28	21.05	
HIV status					
Negative	283	98.26	132	99.25	0.428
Positive	5	1.74	1	0.18	
Complications during pregnancy					
Yes	131	45.49	54	40.60	0.348
No	157	54.51	79	59.40	
Chronic illness before pregnancy					
Yes	77	26.74	32	24.06	0.560
No	211	73.26	101	75.94	
Gestational age at delivery (weeks)					
< 37	90	31.25	123	93.18	< 0.001
37 – 42	198	68.75	9	6.82	

* Chi-square test.

Associations between having SGA-newborn and body mass index controlled for other factors using logistic regression

BMI of the mother before pregnancy was not significantly associated with having SGA newborns (*P*-value = 0.229) (Table 1). It was worth noting that among mothers with SGA newborn, the number of mothers with normal BMI was about 2 times of those with lower than normal one (146 and 72 women, respectively); while among mothers with non-SGA newborn, the number of mothers with normal BMI were about 3.5 times of those with lower than normal one (71 and 22 women, respectively) (Table 1). This discrepancy was consistent with previous finding that pre-pregnancy low BMI was associated with a higher likelihood of having SGA newborn. In addition, once chi-square test was conducted on these four numbers, the resulting *P*-value of 0.099 suggested a possibility that there was significant different risk of having SGA newborn between women with normal BMI and those with lower than normal BMI. While the overall test between having SGA newborn and pre-pregnancy BMI of the mother (four groups of BMI) was not statistically significant (*P*-value = 0.229), ths could be attributable to the fact that the risk of having SGA newborn over different levels of BMI was not identical or linear. Our finding was consistent with the actual risk pattern. In addition, for a preliminary statistical test, a looser *P*-value criterion of < 0.10 for candidate predictors could be applied. Therefore, it deemed appropriate to further carry out logistic regression analysis.

For logistic regression, the assumption of no multicolinearity among independent variables was met with correlation coefficients of each pair of the variables of less than a cutoff value of 0.70.[22] Once all independent variables were controlled for, BMI was significantly associated with having SGA where women with lower than normal BMI had a significantly higher risk of SGA newborn compared to those with normal BMI (OR = 2.392; 95%CI = 1.0677 – 5.3617; *P*-value = 0.034) (Table 3).

It was also found that women with second pregnancy had a significantly lower risk of having SGA newborn compared with those with first pregnancy (OR = 0.404; 95% CI = 0.2063 – 0.7896; *P*-value = 0.008). Women who registered at ANC slightly late (> 12 to 28 weeks) were significantly more likely to have SGA newborn (OR = 2.149; 95% CI = 1.1568 – 3.9943; *P*-value = 0.015), compared with those registered early (1 – 12 weeks). However, those registered very late had a higher risk but with no statistical significance (OR = 1.617; 95% CI = 0.5947 – 4.3960; *P*-value = 0.346)

Women with pregnancy complications had a significantly higher risk of having SGA newborn (OR = 1.988; 95% CI =

Table 3 Relationships between various factors and having small for gestational age (SGA) newborn (N = 421) based on logistic regression.

Factors	Odds ratio	95% CI	*P*-value
Fiscal year			
2017	0.789	0.3895 – 1.6012	0.513
2016	1.271	0.6102 – 2.6470	0.522
2015 (reference)	---	---	---
Demographic characteristics			
Body mass index (kg./m^2)			
Lower than normal (< 19.8 kg/m^2)	2.392	1.0677 – 5.3617	0.034
Higher than normal (> 26.0 to 29.0 kg/m^2)	0.973	0.4112 – 2.3016	0.950
Obese (> 29 kg/m^2)	1.066	0.4578 – 2.4845	0.881
Normal (19.8 – 26.0 kg/m^2) (reference)	---	---	---
Age (years)			
< 20	0.322	0.1235 – 0.8386	0.053
> 35	1.389	0.6469 – 2.9812	0.399
20 - 35 (reference)	---	---	---
Nationality			
Others (Myanmar, Laos, Cambodia, others)	0.510	0.1982 – 1.3127	0.163
Thai (reference)	---	---	---
Healthcare payment scheme			
Out-of-pocket / no insurance	---	---	0.445
Having insurance (reference)	---	---	---
Smoking			
Yes	1.695	0.0879 – 32.6870	0.727
No (reference)	---	---	---
Alcohol intake			
Yes	0.442	0.0384 – 5.0899	0.513
No (reference)	---	---	---
Pregnancy and ANC related characteristics			
Number of pregnancy			
2	0.404	0.2063 – 0.7896	0.008
3	0.607	0.2556 – 1.4405	0.257
4 – 5	0.313	0.0938 – 1.0482	0.060
1 (reference)	---	---	---
Gestational age at ANC registration (weeks)			
> 12 to 28	2.149	1.1568 – 3.9943	0.015
> 28	1.617	0.5947– 4.3960	0.346
1 – 12 (reference)	---	---	---
Continuity of ANC care			
Imperfect follow-up	1.563	0.8321 – 2.9376	0.165
Perfect follow-up (reference)	---	---	---
Hematologic status			
Both Hct and Hb were abnormal	0.666	0.3018 – 1.4690	0.314
Either Hct or Hb was abnormal	0.676	0.3502 – 1.3031	0.242
Both Hct and Hb were normal (reference)	---	---	---
HIV status			
Positive	0.206	0.0183 – 2.3121	0.200
Negative (reference)	---	---	---
Complication during pregnancy			
Yes	1.988	1.0760 – 3.6738	0.028
No (reference)	---	---	---
Chronic illness before pregnancy			
Yes	1.375	0.6975 – 2.7104	0.358
No (reference)	---	---	---
History of pre-term delivery			
Yes	2.467	0.2919 – 20.8417	0.407
No (reference)	---	---	---
History of low birth weight newborn			
Yes	0.1165	0.0012 – 11.4352	0.358
No (reference)	---	---	---
Gestational age at delivery (weeks)			
< 37	50.191	21.6794 – 116.1989	< 0.001
37 – 42 (reference)	---	---	---
Pseudo R^2 = 0.3708 , *P*-value < 0.001			

1.0760 – 3.6738; *P*-value = 0.028) compared with those with no complications. Finally, women delivering the newborn prematurely (gestational age at delivery of less than 37 weeks) had a significantly higher risk of SGA newborn (OR = 50.191; 95% CI = 21.6794 – 116.1989; *P*-value < 0.001) compared with those with gestational age at delivery of 37 – 42 weeks. These independent variables together accounted for 37.08% of variance of SGA newborn status significantly (*P*-value < 0.001) (Table 3). This model of significant independent variables was well fit with the data (Hosmer and Lemeshow Goodness-of-Fit test χ^2 = 6.02, *P*-value = 0.645).

In addition, from fiscal years 2015 to 2017, SGA newborns were more likely to be found in mothers with BMI of less than 19.8 kg/m^2 (24.69%, 33.93% and 14.74% of all mothers regardless of BMI, in year 2015, 2016 and 2017, respectively); while fewer non-SGA newborns were found (17.78%, 19.24% and 11.11%, respectively) (Figure 1). This could be concluded that in each fiscal year from 2015 to 2017, mothers with low BMI (less than 19.8 kg/m^2) had more SGA newborns than non-SGA ones.

Discussions and Conclusion

In this present study examining relationships between low BMI of the mother before pregnancy and small for gestational age (SGA) newborn, pre-pregnancy low BMI of the mother (< 19.8 kg/m^2) had more chance of having SGA newborn (or less than 10 percentile) by 2.39 times of those with normal BMI (19.8 – 26.0 kg/m^2) (OR = 2.392; 95% CI = 1.0677 – 5.3617). This could be due to the fact that BMI is a direct nutritional evaluation for pregnant individuals regardless of age. This preliminary nutritional assessment using weight before pregnancy and height could be a simple determinant of how pregnant women nutrition should be to suit gestational age and respective weight gain.[23]

This nutritional adjustment could refer to how to balance the basic five diet groups to improve the weight and health of both the mother and fetus. At each gestational age, the mothers' weight gain with a lower rate or not in proportion with their BMI could be a result of the mother malnutrition. If not identified and managed by nurses or physicians, maternal malnutrition could continue and result in fetal malnutrition, growth retardation, small to gestational age, and ultimately low birth weight of the newborn. This problem is more prominent in mothers with low BMI who could have a higher risk of stillbirth.[24] Nurses and physicians taking care of pregnant women should plan and counsel nutrition proper for individual women based on their BMI.

Other certain factors were found to be associated with the risk of SGA newborn. Number of pregnancy was significantly related to SGA newborn where the second pregnancy was associated with a 0.40 times of the risk of SGA newborn of the first pregnancy (OR = 0.404; 95% CI = 0.2063 – 0.7896). This could be attributable to the fact that women with their first pregnancy could have less experience and understanding in self-care than their second pregnancy. In addition, the first

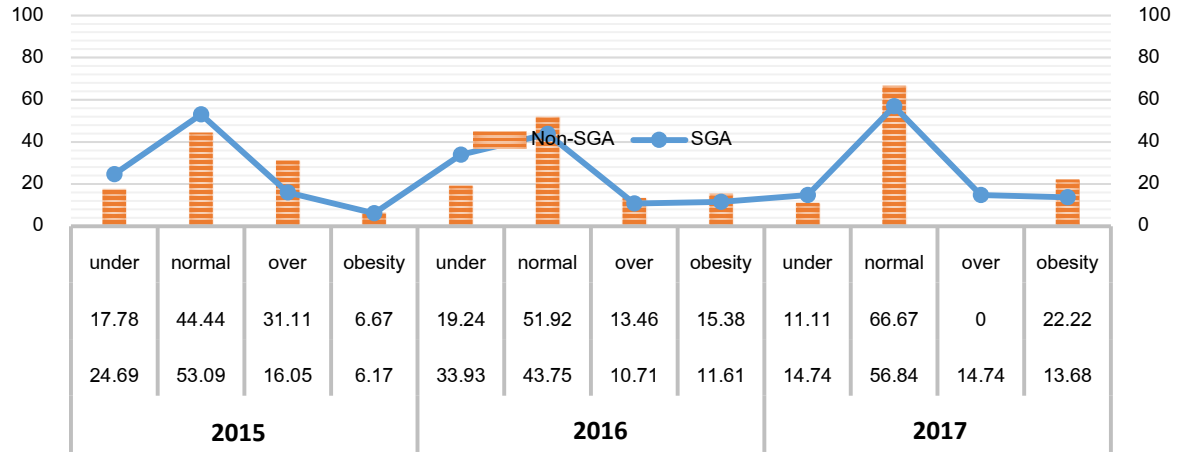

Figure 1 Proportions of SGA and non-SGA newborns by the mother's body mass index (BMI) before pregnancy, from fiscal years of 2015 to 2017. **Note:** under = under normal body mass index (BMI), normal = normal BMI, over = over normal BMI.

pregnancy could be associated with less readiness and hence more anxiety than the second pregnancy. More adversities in the first pregnancy could lead to more unawareness to proper nutritional care which could lead to less maternal weight gain improper to gestational age and BMI. Fetal growth retardation and newborn with low birth weight are the ultimate result.[13]

The time of ANC registry was associated with a significantly higher risk of SGA. The risk of having SGA newborn among women registered in the ANC clinic in the second trimester was 2.15 times of those registered in the first trimester (OR = 2.149; 95% CI = 1.1568 – 3.9943). This could be attributable to the fact that the earlier ANC registry could offer a more thorough and continuous care, and ultimately a better newborn weight. Pregnant women with ANC registry as late as week 12 of pregnancy were more likely to have newborns with low to very low birth weight than those registered before the first 12 weeks of pregnancy. [27,26]

Gestational complications were significantly associated with SGA newborn. The risk of having SGA newborn among women with gestational complications was 1.99 of those with no complications (OR = 1.988; 95% CI = 1.0760 – 3. 6738). This could be due to the fact that complications such as diabetes, anemia and hypertension during pregnancy could affect systemic circulation of the mother especially in blood vessels around placenta which are oxygen and nutrient exchange area for the fetus. The defect of oxygen and nutrient exchange could lead to fetal growth retardation and consequent low birth weight of the newborn.[4,27] Mothers with gestational complications were 2.2 times more likely to have SGA newborns when compared with those with no complications.[28] This risk is even more prominent among mothers with severe hypertension and anemia during pregnancy.[29]

Gestational age at delivery was also significantly associated with SGA newborn. The risk of having SGA newborn among mothers delivering the newborn at the gestational age of less than 37 weeks was 50.19 times of those delivering at the gestational age of 37 – 42 weeks (OR = 50.191; 95% CI = 21.6794 – 116.1989). Since fetus grows with gestational age, at 36 weeks the fetus is 32 centimeters in length and 2,500 grams in weight and has almost completely developed organs. While at 40 weeks, the fetus fully grows with 36 centimeters in length and 3,400 grams. At 40 weeks, the fetus is ready for delivery. Once delivered, the newborn could live if no complications.[30] Newborns delivered at 36 weeks of gestational age were more likely to have the body weight of less than 2,500 grams[31] or less than 10 percentile of their respective gestational age, especially in the third trimester of the pregnancy.[32]

This study had certain limitations. With its retrospective design, the mother's weight before pregnancy was less reliable than those obtained prospectively. As a result, the BMI was less reliable. This bias could be more severe in the mothers registered at the ANC late in their pregnancy. In addition, the weight gained throughout the pregnancy period could be incomplete therefore this factor could be biased in predicting the newborn weight.

In conclusion, pre-pregnancy BMI of the mother could affect the newborn's body weight. Mother with low body mass index should be recommended on proper nutrition to avoid the risk of small for gestational age newborn.

References

1. Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Rouse DJ, Spong CY. Williams obstetrics. New York. McGraw-Hill, 2014.
2. Redline RW. Placental pathology: a systematic approach with clinical correlations. *Placenta* 2008;29(suppl A):S86-91.
3. Murki S, Sharma D. Intrauterine growth retardation - A review article. *J Neonatal Biol* 2014;3(3):1-13.
4. Albu AR, Anca AF, Horhoianu VV, Horhoianu IA. Predictive factors for intrauterine growth restriction. *J Med Life* 2014;7(2):165-171.
5. Watanabe H, Inoue K, Doi M. Risk factors for term small for gestational age infants in women with low prepregnancy body mass index. *J Obstet Gynaecol Res* 2010;36(3):506-512.
6. Sbârcea A, Râcă N. Evaluation of risk factors involved in intrauterine growth restriction. *Studia Universitatis" Vasile Goldis" Arad Seria Stiintele Vietii (Life Sciences Series).* 2012;22(2):225-233.
7. Haram K, Søfteland E, Bukowski R. Intrauterine growth restriction: effects of physiological fetal growth determinants on diagnosis. *Obstet Gynecol Inter* 2013;2013: 708126. (doi: 10.1155/2013/708126)
8. Figueras F, Gardosi J. Intrauterine growth restriction: new concepts in antenatal surveillance, diagnosis, and management. *Am J Obstet Gynecol* 2011;204(4):288-300.
9. Figueras F, Gratacós E. Update on the diagnosis and classification of fetal growth restriction and proposal of a stage-based management protocol. *Fetal Diagn Ther* 2014;36(2):86–98.
10. Kaur S, Ng CM, Badon SE, et al. Risk factors for low birth weight among rural and urban Malaysian women. *BMC Pub Health* 2019;19(suppl 4):539. (doi: https://doi.org/10.1186/s12889-019-6864-4)
11. Olusanya BO. Intrauterine growth restriction in a low-income country: Risk factors, adverse perinatal outcomes and correlation with current

WHO Multicenter Growth Reference. *Early Hum Dev* 2010;86(7):439-444.

12. Haslinger C, Bamert H, Rauh M, Burkhardt T, Schäffer L. Effect of maternal smoking on stress physiology in healthy neonates. *J Perinatol* 2017;38(2):132-136.
13. Jaranil U, Kuhirunyarat P, Nimitwongsakul O. Pregnancy factor affects low birth weight at Nong Bua Lum Phu Hospital, Nong Bua Lum Phu province. Paper presented at Graduated Research Conference 2014. Khon Kaen. Khon Khen University, 2014. (in Thai)
14. Anchaleechamaikorn P. Factors related to low birth weight newborns at Chaoprayayommaraj Hospital, Supanburi province. *Nurs J Ministry Pub Health* 2011;21(1):71-79. (in Thai)
15. Ota E, Haruna M, Suzuki M, et al. Maternal body mass index and gestational weight gain and their association with perinatal outcomes in Viet Nam. *Bull World Health Organ* 2011;89(2):127-136.
16. Crane JM, White J, Murphy P, Burrage L, Hutchens D. The effect of gestational weight gain by body mass index on maternal and neonatal outcomes. *J Obstet Gynaecol Can* 2009;31(1):28-35.
17. Han Z, Mulla S, Beyene J, Liao G, McDonald SD. Maternal underweight and the risk of preterm birth and low birth weight: a systematic review and meta-analyses. *Inter J Epidemiol* 2011;40(1):65-101.
18. Kozuki N, Lee ACC, Silveira MF, et al. The associations of birth intervals with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. *BMC Pub Health* 2013;13(suppl 3):S3. (doi: 10.1186/1471-2458-13-S3-S3)
19. Dall'Asta A, Brunelli V, Prefumo F, Frusca T, Lees CC. Early onset fetal growth restriction. *Matern Health Neonatol Perinatol* 2017;3:2. (doi: 10.1186/s40748-016-0041-x)
20. Dankul W, Ratanasathien L. Antenatal care and factors affecting birth weight: Multinomial logistic regression. *J Nurs Sci Chulalongkorn Univ* 2018;30(2):54-69. (in Thai)
21. Borisut P, Kovavisarach E. Standard intrauterine growth curve of thai neonates delivered at rajavithi hospital. *J Med Assoc Thai* 2014;97(8): 798-803.
22. Devore JL, Peck R. Statistic: The exploration and analysis of data. New York. Duxbury Press, 1993.
23. Boontheap P. Assessment of nutritional status. 2008. (Accessed on Jul. 4, 2019, at http://www.med.cmu.ac.th/dept/nutrition/DATA/COMMON/cmunut-deptped/ped401-prasong/ped401-assessment-of-nutritional-prasong.pdf) (in Thai)
24. Williams M, Southam M, Gardosi J. Antenatal detection of fetal growth restriction and stillbirth risk in mothers with high and low body mass index. *Arch Dis Child Fetal Neonatal Ed* 2010;95(suppl X):Fa90-Fa111.
25. Tantayakom C, Prechapanich J. Risk of low birth weight infants from adolescent mothers: Review case study in siriraj hospital. *Thai J Obstet Gynaecol* 2008;16(2):103-108.
26. Khammas E. Disparities of clinical features and associated maternal factors among symmetrical and a symmetrical intra-uterine growth restriction (iugr) in nicu at al-yarmouk teaching hospital in Baghdad, Iraq. *Inter J Pediatr* 2018;6(6):7815-7822.
27. Sharma D, Shastri S, Sharma P. Intrauterine growth restriction: Antenatal and postnatal aspects. *Clin Med Insight Pediatr* 2016;10:67-83.
28. Ernst SA, Brand T, Reeske A, Spallek J, Petersen K, Zeeb H. Care-related and maternal risk factors associated with the antenatal nondetection of intrauterine growth restriction: A case-control study from Bremen, Germany. *Biomed Res Inter* 2017;1746146. (doi: 10.1155/2017/1746146)
29. Low JA, Galbraith RS. Pregnancy characteristics of intrauterine growth retardation. *Obstet Gynecol* 1974;44(1):122-126.
30. Cunningham FG, Leveno KJ, Bloom SL, et al. Williams obstetrics. USA. McGraw-Hill, 2014.
31. Trainapakul C. Related factors of low birth weight infants at Ratchaburi Hospital. *Region 4-5 Med J* 2017;36(2):79-87. (in Thai)
32. Gilbert WM, Danielsen B. Pregnancy outcomes associated with intrauterine growth restriction. *Am J Obstet Gynecol* 2003;188(6):1596-1599.