Original Article

Pre-pregnancy body mass index as a predictor of low birth weight infants in Japan

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Background and Objectives: The prevalence of low birth weight (LBW) infants in Japan has doubled in the last several decades. The objective of this study was to examine the effects of pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) on LBW infants of Japanese women. **Methods and Study Design:** This retrospective study was conducted using data on 1,336 mothers (mean age, 34.0 years) whose pre-pregnancy BMI was less than 23 kg/m^2 and their singleton infants were born at full term between January and December in 2011. The outcome of interest was LBW infants (less than 2,500 g). The main exposure variables were pre-pregnancy BMI and GWG. The effects of these two variables on LBW were determined after adjusting for confounder variables such as maternal age, smoking, drinking, parity, gestational week at birth and infant gender. **Results:** The proportion of LBW infants was 4.2% in total, 6.1% among underweight mothers (<18.5 kg/m^2) and 3.5% among normal weight mothers (18.5-22.9 kg/m^2). A stepwise multivariable logistic regression model showed that underweight mother were more likely [odds ratio (OR) 1.86, 95% confidence interval (CI), 1.04-3.31] than normal weight mother to deliver a LBW infant. Mothers with inadequate GWG <8.5 kg were more likely to deliver a LBW infant (OR 1.66, 95% CI: 0.80-3.45) compared with mothers who gained 10.5-12.4 kg (the third lowest quartile) but this did not reach statistical significance. **Conclusions:** This study demonstrated that mothers who were underweight before pregnancy were independently associated with the delivery of LBW infants.

Key Words: gestational weight gain, Japan, low birth weight, pre-pregnancy body mass index, underweight

INTRODUCTION

The prevalence of low birth weight (LBW) infants in Japan has nearly doubled during last several decades (4.6% in 1975 and 8.3% in 2009).[1,2] LBW children are more likely to have subnormal growth, neuro developmental disorder and problems in cognition, attention, and motor function.[3] The consequences of being born at a LBW might become apparent in adolescence and adulthood.[4] These developmental sequelae have substantial impact on social and economic situation of a country.

Evidence accumulating from published studies has indicated that maternal factors including being underweight and inadequate gestational weight gain (GWG) are associated with a higher risk of LBWinfants.[5,6] However, these findings are largely based on studies conducted in Western countries. As the prevalence of underweight Asian women has been reported to be substantially higher than in countries of the Organization for Economic Cooperation and Development (OECD),[7] the overall impact of underweight mothers on birth weight is expected to be much higher in Asian countries. For example, the prevalence of underweight women was 10.4% in 2011 in Japan compared with an average of 4.1% in OECD countries.[7] Moreover, the prevalence of underweight women in their 20s was even higher (22%).[8] Thus, the lack of studies conducted in Asian countries that examined maternal factors as correlates of LBW, are a significant omission in the literature. In addition, the findings generated from these types of studies are not consistent,[9-16] which may be due to differences in study design, number of maternal factors included or sample size. Likewise, the effect of pre-pregnancy Body Mass Index (BMI) and/or GWG on LBW differs among studies. Thus, the purpose of this study was to examine the effects of pre-pregnancy BMI

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and GWG on LBW among Japanese women.

MATERIALS AND METHODS

We conducted a retrospective review of the electronic medical records (EMRs) of all women who delivered between January 2011 and December 2011 at the Japanese Red Cross Medical Center in the Tokyo metropolitan area. With approval from the Ethics Committee of the Teikyo University School of Medicine (TU-COI 13-1592), the EMRs of 2,182 women were reviewed by 2 trained study coordinators. Data were recorded onto a standardized data collection form. After excluding multiple pregnancies (n=81), preterm births (n=253), miscarriages (n=220) and stillbirths (n=10), we were left with the EMRs of 1,618 mothers and their infants born at ≥37 weeks gestation from singleton pregnancies. Then, we excluded EMRs if the baby was born at ≥42 weeks gestation (n=8); if the mother had gestational diabetes (n=58), pregnancy-induced hypertension (n=67), or a pre-pregnancy BMI of ≥23.0 kg/m^2 (i.e., overweight/ obese based on the WHO BMI definitions for Asian people;[17] n=139); and if data were missing on drinking (n=5), gestational weight gain (n=1) and delivery method (n=4). Thus, our final analysis was based on 1,336 EMRs.

Items retrieved from the medical records were maternal age, maternal body weight and height measured at the first prenatal check up and at the time of hospitalization for delivery, gestational weight change, and lifestyle variables including smoking and drinking habits recorded at the first medical visit and during pregnancy. Other variables included parity, delivery method (cesarean or vaginal delivery), birth of a LBW infant (<2,500 g), gestational week at birth, and infant gender.

Pre-pregnancy BMI was calculated as weight (kg) divided by the square of height (m^2), and divided into categories of underweight (<18.5 kg/m^2) and normal weight (18.5-22.9 kg/m^2).[17] Gestational weight gain (GWG, kg) was computed as the difference between pre-pregnancy weight and weight measured at the time of delivery, and was grouped into quartiles.

Bivariate analyses were conducted using ANOVA, chi-square or Fisher's exact tests as appropriate. A logistic regression model was used to investigate the effects of pre-pregnancy BMI and GWG on LBW (i.e., the dependent variable) and a stepwise multivariable model was used, adjusting for covariates. Finally, we included the interaction term between pre-pregnancy BMI and GWG to examine the existence of an additive or multiplicative effect of these two variables on their association with LBW. All analyses were performed using SAS 9.3 statistical software (SAS Institute, Cary NC, USA).

RESULTS

Table 1 shows the characteristics of the study population. Approximately half of the sample were ≥35 years old. One-quarter of the women were underweight while a similar percentage of women had a GWG <8.5 kg, the lowest quartile. The prevalence of LBW was 4.2%. The majority of women were primiparous and had vaginal delivery. Approximately one-fifth of the women had a history of smoking or drinking.

Table 1. Characteristics of study population (n=1,336)

	N	%
Maternal age (years)		
<30	256	19.2
30-34	463	34.7
35-39	464	34.7
≥40	153	11.5
Pre-pregnancy BMI (kg/m^2)		
<18.5	347	26
18.5-22.9	989	74
Gestational weight change (kg)		
1th lowest quartile (<8.4)	333	24.9
2th lowest quartile (8.5-10.4)	310	23.2
3th lowest quartile (10.5-12.4)	323	24.2
4th lowest quartile (≥12.5)	370	27.7
Maternal life behaviours		
Smoking	253	19
Drinking	308	23.1
Parity		
Primiparous	830	62.2
Multiparous	506	37.8
Delivery method		
Cesarean delivery	190	14.2
Vaginal delivery	1146	85.8
Gestational week at birth (week)		
37-38	309	23.1
39	429	32.1
40	427	32
41	171	12.8
Child's birth weight (g)		
<2500	56	4.2
≥2500	1280	95.8

PIH: pregnancy-induced hypertension; GDM: Gestational diabetes mellitus

Table 2 shows the bivariate associations with LBW and the results of the logistic regression of risk factors for LBW infants. The prevalence of LBW was significantly higher among those who were underweight, primiparous, had low GWG, and delivered at 37-38 weeks gestation. After adjusting for the covariates selected by the stepwise method, a multivariable logistic regression model showed that pre-pregnancy BMI <18.5 kg/m^2, being primiparous, and earlier gestational week at birth were independently associated with a higher odds ratio of LBW. Underweight mother were more likely [odds ratio (OR) 1.86, 95% confidence interval (CI), 1.04-3.31] than normal weight mothers to deliver a LBW infant. Mothers with inadequate GWG <8.5 kg were more likely to deliver a LBW infant (OR 1.66, 95% CI: 0.80-3.45) compared with mothers who gained 10.5-12.4 kg (the third lowest quartile) but this did not reach statistical significance. No significant interaction was observed between pre-pregnancy BMI and GWG with LBW.

DISCUSSION

This study demonstrated that being underweight was independently associated with LBW.As the prevalence of underweight, reproductive-aged women is higher in Japan than in other countries,[7] an awareness program related to optimum body weight during childbearing years can play vital role in lowering the incidence of LBW infants.

Several studies conducted in East Asian countries on the association of pre-pregnancy BMI and/or GWG with

Table 2. Bivariate associations with LBW and logistic regression results of risk factors for LBW infants

	LBW		Univariate				Stepwise logistic model			
			Odds	95% CI		*p*	Odds	95% CI		*p*
	n	%		Lower	Upper			Lower	Upper	
Age (year)						0.829	-	-	-	
<30	14	5.5	1.00							
30-34	13	2.8	0.5	0.23	1.08					
35-39	21	4.5	0.82	0.41	1.64					
40≤	3	5.2	0.95	0.39	2.33					
Pre-pregnancy BMI (kg/m^2)						0.047				0.035
<18.5	21	6.1	1.76	1.01	3.06		1.86	1.04	3.31	
18.5-22.9	35	3.5	1.00				1.00			
GWG (kg)						0.001				0.027
1th lowest quartile (<8.5 kg)	26	7.8	2.20	1.09	4.43		1.66	0.8	3.45	
2th lowest quartile (8.5- 10.4 kg)	13	4.2	1.13	0.51	2.53		1.07	0.47	2.43	
3th lowest quartile (10.5-12.4 kg)	12	3.7	1.00				1.00			
4th lowest quartile (≤12.5 kg)	5	1.4	0.36	0.12	1.02		0.37	0.13	1.08	
Maternal life behaviours										
Smoking						0.833				
Yes	10	4.0	0.93	0.46	1.86		-	-	-	
No	46	4.3	1.00				-	-	-	
Drinking						0.536				
Yes	11	3.6	0.81	0.41	1.58		-	-	-	
No	45	4.4	1.00				-	-	-	
Parity						0.006				0.001
Primiparous	45	5.4	2.58	1.32	5.03		3.03	1.53	6	
Multiparous	11	2.2	1.00				1.00			
Gestational age (week)						<0.001				<0.001
37-38	30	9.7	9.09	2.14	38.5		8.26	1.91	35.7	
39	17	4.0	3.49	0.8	15.3		3.37	0.76	14.9	
40	7	1.6	1.41	0.29	6.85		1.49	0.31	7.29	
41	2	1.2	1.00				1.00			
Infant sex						0.466				
Girls	30	4.6	1.22	0.71	2.09		-	-	-	
Boys	26	3.8	1.00				-	-	-	

LBW: low birth weight; GWG: gestational weight gain.

LBW have reported inconsistent results, which is most likely due to methodological differences among the studies. For example, Ronnenberg et al[9] reported non-significance between underweight mothers and LBW, but the total sample size was the smallest among previous studies. Tsai et al[16] found a significant effect of inadequate GWG in underweight mothers, but the confidence interval was relatively wide due to the small number of underweight mothers. The discrepancies in the effect of pre-pregnancy BMI and/or GWG on LBW among different studies could also be due to the different classifications of GWG used in these studies.[8,9,11-13,15] In contrast, the sample size of the present study was relatively larger with a higher proportion of underweight mothers (one-fourth of the total sample), which is the strength of our study.

In this study, we observed that 4% of the infants had a LBW, which is almost half of the value reported in a recent survey based on the general population in Japan (9.6%).[18] The lower rate of LBW could be due to the fact that the study setting is one of the most famous maternity hospitals in the Tokyo area and the expectant mothers tend to be more health-conscious, which might favourably influence delivery outcome. We did not find any significant association between maternal age and LBW, although a study conducted in China reported a higher likelihood of LBW among younger and older mothers.[13]

This study has several limitations that need to be addressed. First, our study was based on one hospital in Tokyo. Second, as we did not have data on infant height, we were not able to compute small for gestational age (SGA), a measurement that could shed more light on our findings. However, published studies conducted in Eastern Asian countries and a meta-analysis observed a higher risk of SGA among underweight mothers,[5,19-22] which is consistent with our results. Third, in this study, we did not find an association between smoking/drinking and LBW, most likely due to the low prevalence of smoking and drinking among mothers in this study, which requires careful interpretation. Finally, as we had a small number of LBW infants in the 4th lowest quartile of GWG, a future study with a larger sample size is warranted to confirm our findings.

In conclusion, this study demonstrated that being underweight was independently associated with LBW. In Japan, where many women of childbearing age are underweight, clinicians, public health practitioners and policy makers should be actively involved in education to increase awareness among mothers of the importance of maintaining their weight within a normal range for a safe delivery.

AUTHOR DISCLOSURES

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