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Field Report

Combination of parity and pre-pregnancy BMI and low birth weight infants among Japanese women of reproductive age

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Abstract: This study aimed to examine the effects of parity and pre-pregnancy body mass index (BMI) on low birth weight (LBW) infants among Japanese women. Participants included 1,518 mothers (mean age 34.0 years) of singleton full-term infants in 2011. The incidence of LBW infants was 7.5% in primiparous women with BMI<18.5 (Group A; n=239), 4.0% in multiparous women with BMI<18.5 (Group B; n=124), 6.0% in primiparous women with 18.5≤BMI<25 (Group C; n=715), and 1.8% in multiparous women with 18.5≤BMI<25 (Group D; n=440). A multivariable logistic regression model revealed that mothers in Group A were more likely to deliver a LBW infant [odds ratio (OR) 6.41, 95% confidence interval (CI), 2.65−15.49] than were mothers in Group D. Being both underweight (OR 1.8, 95% CI: 1.05−3.11) and primiparous (OR 3.41, 95% CI: 1.82−6.44) were independently associated with LBW infants. This study demonstrated that the characteristics of primiparous and underweight in mothers are additively associated with LBW infants.

Key words: Low birth weight, Pre-pregnancy body mass index, Parity, Japanese women of reproductive age, Singleton full-term infants

Introduction

In 2014, the average maternal age was 31 years, and the fertility rate was estimated at 1.4 children per woman[1−3]. In fighting a declining birth rates and aging population, more women are expected to enter the workforce to support financial infrastructure of Japan. However, older maternal age and subsequent high rates of primiparity may affect health outcomes among children.

In Japan, 9.6% of infants are classified as low birth weight (LBW). This percentage is greater than the average among Organisation for Economic Co-operation and Development countries. Additionally, the prevalence of LBW infants has been increasing: from 5.2% in 1980 to 9.6% in 2012[6]. This trend is concerning, because LBW infants are at increased risk for non-communicable disease during adulthood. Studies focusing on the Developmental Origin of Health and Disease hypothesis[4,5] suggest that maternal starvation due to malnutrition during pregnancy alters the epigenetic expression of metabolic genes in the fetus[6,7].

According to a 2014 national nutrition survey, 20% of Japanese women in their 20 s and 30 s are underweight[8]. The same survey also reported that the average energy intake among women aged 18−49 years is 1,700 kcal per day, which is considerably less than the energy require-

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ment for women, even those with a sedentary lifestyle[8]. Additionally, Japanese nutrition surveys conducted in 1982 and 2012 revealed that the proportion of underweight women has increased from 12.1% to 21.8% among women in their 20 s and from 8.2% to 17.1% among women in their 30 s, respectively[9]. Being underweight is of serious concern in women of reproductive age, because maternal undernutrition directly reduces the supply of nutrients to the fetus[10]. We recently found that a maternal underweight status increased the risk of having a LBW infant[11].

Because fertility rates have been decreasing, in this study, we focused on the effects of primiparity and poor nutritional status among Japanese women on fetal health. Specifically, we investigated both individual and combined effects of primiparity and underweight on the birth of LBW infants. The result of present study may be useful for public health strategy to help women and children stay healthy contributing to the workforce to support the financial infrastructure of Japan.

Materials and Methods

This retrospective cohort study focused on dyads of mothers and infants born from January – December 2011 at the Japanese Red Cross Medical Center in the Tokyo metropolitan area that has the second largest numbers of delivery in Tokyo. This medical center does not necessarily always receive pregnant women with high risk but pregnant women in general population. The study protocol was approved by the ethics committee at the Teikyo University School of Medicine (TU-COI 13-1592). Data were collected from electronic chart records. We excluded women with multiple pregnancies (n=81), preterm births (n=253), miscarriages (n=220), stillbirths (n=10), post-term births (n=8), a pre-pregnancy BMI≥25 (n=81), and missing data regarding drinking habits (n=6), gestational weight gain (n=1), and caesarian section (n=4). This left us with a total of 1,518 mothers and their singleton infants born at ≥37 weeks gestation.

We investigated factors including maternal age, parity, maternal pre-pregnancy BMI, gestational weight change, and lifestyle variables including smoking and drinking habits recorded at the first medical visit and during pregnancy, the delivery method (caesarean 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 height squared (m^2). Gestational weight gain (kg) was computed as the difference between pre-pregnancy weight and weight at the time of delivery. Pre-pregnancy BMI was calculated as weight (kg) divided by the square of height (m2) and further categorized into underweight (BMI<18.5) and normal (≥18.5 – 25.0) according to the NIH BMI definitions[12].

Outcomes of interest included whether LBW was associated with being underweight (defined as a BMI<18.5) and/or primiparous delivery. We investigated the individual effects of a BMI<18.5 and primiparous delivery and the combined effects of these two variables by dividing participants into four groups: Group A (BMI<18.5 and primiparous; n=239), Group B (BMI<18.5 and multiparous; n=124), Group C (18.5≤BMI<25 and primiparous; n=715), and Group D (18.5≤BMI<25 and multiparous; n=440). 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/or parity on LBW (i.e., the dependent variable), and a stepwise multivariable model was used to adjust for covariates. Model I included individual effect of parity and prepregnancy BMI and Model II included combination of parity and prepregnancy BMI adjusting for covariates selected by a stepwise regression model. Finally, we included the interaction term between pre-pregnancy BMI and parity to explore the additive or multiplicative effects 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

Overall, 23.9% of participants were underweight (n=363), and 62.9% of deliveries were primiparous (n=954). Table 1 lists the characteristics of the study population according to the combination of pre-pregnancy BMI and parity. The prevalence of infants with birth weight less than 2,500 grams were the highest in GroupA, followed by Groups C and B, and then Group D (p=0.002), and mothers in Group C were more likely to have pregnancy-induced hypertension (6.9%) among all groups (p<0.0001). The number of gestational weeks at delivery was comparable among groups.

Table 2 lists the incidences and odds ratios (ORs) with 95% confidence intervals (CIs) for LBW infants. The incidence of LBW infants was 6.4% among primiparous mothers versus 2.3% among multiparous mothers, 6.3% among underweight mothers versus 4.4% among normal weight mothers, 7.5% in Group A (BMI<18.5 and primiparous; n=239), 4.0% in Group B (BMI<18.5 and multiparous; n=124), 6.0% in Group C (18.5≤BMI<25 and primipa-

Table 1. Characteristics of the four combination groups of prepregnancy BMI and parity (n=1,518)

	Group A BMI <18.5 and primiparous n=239 (15.7%)		Group B BMI <18.5 and multiparous n=124 (8.2%)		Group C BMI 18.5–24.9 and primiparous n=715 (47.1%)		Group D BMI 18.5–24.9 and multiparous n=440 (29%)		*P*-value
Maternal age, years	32.0±5.0		34.2±4.7		33.6±5.2		35.5±4.1		<.0001
Gestational weight gain, kilograms	11.2±3.3		10.7±3.3		10.4±3.6		10.0±3.3		0.0004
Pregnancy Induced Hypertension, n (%)	5	2.1	1	0.8	49	6.9	5	1.1	<.0001
Maternal lifestyle									
Cigarette smoking habit, n (%)	50	20.9	17	13.7	156	21.8	64	14.6	0.007
Alcohol drinking habit, n (%)	61	25.5	16	12.9	181	25.3	85	19.3	0.004
Gestational week at delivery, weeks	39.4±1.1		39.0±1.0		39.4±1.1		39.2±1.0		0.0003
									0.003
37, n(%)	13	5.4	9	7.3	36	5.0	24	5.5	
38, n(%)	34	14.2	27	21.8	122	17.1	90	20.5	
39, n(%)	79	33.1	48	38.7	208	29.1	147	33.4	
40, n(%)	80	33.5	31	25.0	230	32.2	143	32.5	
41, n(%)	33	13.8	9	7.3	119	16.6	36	8.2	
Child									
Males, n(%)	130	54.4	60	48.4	364	50.9	228	51.8	0.527
Low Birth weight infant									0.002
<2,500, n(%)	18	7.5	5	4.0	43	6.0	8	1.8	
2,500 ≤, n(%)	221	92.5	119	96.0	672	94.0	432	98.2	

Table 2. Incidence and odds ratio (OR) with 95% conficencial interval (CI) for low birth weight infant

	low birth weight infant n (%)	Logistic regression model: Crude OR (95% CIs)	Multivariate stepwise model*: Adjusted OR	95% CI Lower	95% CI Upper
Model I					
Parity					
Primiparous	61 (6.4)	2.90(1.58, 5.32)	3.41	1.82	6.44
Multiparous	13 (2.3)	1.00	1.00	–	–
Prepregnancy BMI, kg/m^2					
<18.5, n(%)	23 (6.3)	1.46 (0.88, 2.43)	1.80	1.05	3.11
18.5–24.9, n(%)	51 (4.4)	1.00	1.00	–	–
Model II					
Combination of parity and prepregnancy BMI					
Group A (n=239)					
BMI <18.5, Primiparous	18 (7.5)	4.40 (1.88, 10.27)	6.41	2.65	15.49
Group B (n=124)					
BMI <18.5, Multiparous	5 (4.0)	2.27 (0.73, 7.06)	2.28	0.71	7.34
Group C (n=715)					
BMI 18.5–24.9, Primiparous	43 (6.0)	3.46 (1.61, 7.42)	3.78	1.72	8.33
Group D (n=440)					
BMI 18.5–24.9, Multiparous	8 (1.8)	1.00	1.00	–	–

*Adjusting for factors groups (or parity and prepregnancy BMI), age, infant sex, Pregnancy Induced Hypertension, gestational week at delivery, gestational weight gain, cigarette smoking habit, alcohol drinking habit.
Model I included individual effect of parity and prepregnancy BMI and Model II included combination of parity and prepregnancy BMI.

rous; n=715), and 1.8% in Group D (18.5≤BMI<25 and multiparous; n=440). In both Model I and II, variables selected by a stepwise regression model included an individual variable of parity ($p<0.001$) and prepregnancy BMI ($p=0.034$) or combination ($p<0.001$), continuous gestational weight gain (both ps<0.0001), PIH (both ps=0.001) and gestational week (both ps < 0.0001). Model I revealed that being both underweight (OR 1.80, 95% CI: 1.05–3.11) and primiparous (OR 3.41, 95% CI: 1.82–6.44) were independently associated with LBW. No significant interactions were observed between pre-pregnancy BMI or parity and LBW. Model II demonstrated that mothers in Group A were more likely (OR 6.41, 95% CI: 2.65–15.49) than mothers in Group D to deliver a LBW infant. In both Model I and II, gestational weight gain (OR 0.84, 95%CI: 0.78–0. 90 in both Models) and later gestational week (OR 0.48, 95%CI: 0.38 0.61 in both Models) were negatively associated with the risk of LBW, and the presence of PIH was positively associated with the risk of LBW (OR 4.00, 95%CI: 1.76–9.11 in Model I and OR 3.97, 95%CI:1.74–9.04 in Model II).

Discussion

The results of this study demonstrated that being underweight and a primiparous delivery were independently associated with LBW infants. The combined effect of pre-pregnancy BMI and parity was additive; being underweight and a primiparous delivery additively increased the risk of delivering a LBW infant.

A previous meta-analysis demonstrated that singletons born to underweight mothers are at increased risk of being LBW than are those born to mothers of normal weight (adjusted OR 1.64, 95% CI: 1.38–1.94)[10]. Although most previous studies on this topic were conducted outside East Asia, two studies conducted in East Asia[13, 14] reported that underweight mothers were at an increased risk of delivering a LBW infant, supporting our findings[11]. We also found that primiparous delivery and being underweight among Japanese women of childbearing age are both independently associated with the delivery of LBW infants.

Unlike studies regarding the relationship between underweight mothers and LBW infants, to our knowledge no studies have explored the relationship between parity and LBW in Japan. Interestingly, birth order appears to be associated with the risk of LBW. According to a 2015 national survey, first children tend to weigh less than second or subsequent children[15]. Previous studies focusing on twins[16, 17], which commonly have birth weight discordance, have reported that the incidence of LBW infants is higher among primiparous deliveries compared with multiparous deliveries, suggesting that the uteri of multiparous women may be more efficient in promoting intrauterine fetal growth. Our findings revealed that primiparous delivery increased the risk of LBW almost three-fold compared with being underweight, so this factor should not be ignored.

Currently, many young Japanese women, even school girls, focus excessively on being slim and tend to eat nutritionally unbalanced meals[18]. In response to this issue, the Shokuiku Basic Act was passed in 2005 to encourage adequate food and nutrition among children and adults[19]. The word 'Shokuiku' refers to intellectual, moral, and physical education and food choice skills. However, the trend of being underweight (i.e., BMI < 20 kg/m^2 according to the nutrition survey design) has not changed since the establishment of the Basic Act on Food Education in 2006 (from 43% in 2006 to 43% in 2013 among women in their 20 s and 30 s)[20]. To address this problem, it is important to improve disturbed perceptions of body image and introduce healthy diets to maintain appropriate weight[21]; food and nutrition educators should work with health professionals in fields including clinical psychology, body-psycho somatic medicine, psychiatry, and neurology[22].

Fertility rates are increasing in European countries but decreasing in Japan, as the number of women entering the workforce is increasing[2, 3]. The relationship between low fertility rates and increasing female participation in the workforce has also been observed in European countries, where marrying or giving birth used to have significantly negative effects on a woman's decision to stay in the workforce. However, as services and supporting infrastructures for child caring are being implemented, it has become more feasible for European women to balance child rearing and participation in the workforce. In Japan, many women are still struggling to combine family responsibilities with participation in unsupportive workplaces, for example those lacking daycares. Thus, the Japanese social infrastructure needs to be improved to help women balance family responsibilities and work, thereby increasing the number of women entering workforce. Indeed, in aging society of Japan with declining birthrate, women are promising population in workforce to support financial infrastructure of Japan.

A LBW infant is defined as one weighing less than 2,500 g, regardless of gestational age. Preterm infants are usually LBW; however, even though the prevalence of LBW infants in Japan has increased from 5.2% in 1980 to 9.6% in 2012 (+4.4% increase)[6], preterm birth rates have increased only slightly (from 4.1% in 1980 to 5.7% in 2012, +1.6% increase)[9]. One strength of this study is that we were able to investigate the determinants of LBW among full-term infants, excluding the effects of preterm delivery.

However, this study had several limitations. First, it included a study population from a single hospital in Tokyo, which limits the generalizability of the findings to some extent. For example, mean age of our subjects was 33 years and slightly older than a representative sample of Japanese women in the general population (i.e., average maternal age 31 yrs). Furthermore, because the hospital has the second largest numbers of deliveries in Tokyo, the percentages of high risk pregnant women in this hospital might be higher than general population of pregnant women. Second, we did not have data on infant height, so we were unable to compute small for gestational age status. Third, although we considered lifestyle factors including smoking and drinking, our data were collected at the first prenatal visit, so some misclassification might have occurred. Therefore, our results should be interpreted carefully.

In conclusion, our results demonstrated that primiparous delivery and underweight status are both independently associated with LBW, and the combined effect of the two factors increased this association. Within the Japanese context of an increasing number of women entering the workforce, it is important to consider the increasing age of pregnant women[5]. Additionally, maternal nutrition throughout pregnancy is extremely important to ensure the infant's health during adulthood. Finally, considerable improvements to the social infrastructure are needed to help women balance child rearing and work; this could increase the declining birth rates in Japan.

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