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Maternal Body Mass Index Correlates with the Neonatal Physique of Male Infants

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Recently, in Japan, the percentage of leanness has risen in young women, and the average birth weight has decreased. An increase in the risk of low birth weight has been reported in lean expectant mothers. In this study, we aimed to clarify the relationship between mother's physique at the beginning of pregnancy and the infant's physique, by focusing on sex differences. The participants were 3,722 mothers who attended health checkups for 18-month-old infants in an urban Japanese city. The participants were limited to those with full-term births, thereby excluding the influence of gestational length. A total of 1,287 mothers, with 621 boys and 666 girls, were analyzed. Public health professionals interviewed the mothers, and transferred the required information from their maternity passbooks. We examined the physical characteristics of the mothers and their infants. Partial correlation analysis, adjusted by gestational length and the mother's age at delivery, was applied to study the association between the mother's BMI and the infant's physique at birth. In the primipara group, only the boys showed significant positive correlation between the mother's BMI and the birth weight (P = 0.025) and the Kaup index (P = 0.035). In the pluripara group, only the boys showed significant positive correlation between the mother's BMI and the head circumference (P = 0.035). Thus, mother's physique may have a stronger influence on the physique of male infants, compared to female infants. The growth-promoting effect of the mother's physique is more apparent in the infants born to the pluripara.

Keywords: birth weight; infants; mothers; physique; sex
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Introduction

According to data published by the National Nutrition and Health Survey in Japan in 2010, the percentage of leanness was 29.0% in women for twenty generations and 14.4% in women for thirty generations (National Institute of Health and Nutrition 2012). These results show that the percentage of leanness has risen. On the other hand, the average birth weight has decreased (National growth survey on preschool children in Japan in 2010) (Ministry of Health, Labour and Welfare 2010a). Increases in the risk of low birth weight infants have been reported in lean expectant mothers, compared with expectant mothers with normal physiques (Sebire et al. 2001; Ehrenberg et al. 2003; Watanabe et al. 2010; Ye et al. 2010).

According to previous animal studies, the effect of energy restrictions during pregnancy on the physique of infants was clearly shown in males pups, compared with female pups (Chow and Lee 1964). Furthermore, BMI rose for boys after the age of three due to the effect of smoking during pregnancy (Suzuki et al. 2011). Therefore, there is the possibility that the effect of the mother's physique on the physique of infants is different, depending on the sex of the infant. However, only a few studies have examined sex and the relationship between the body size of infants at birth and the physique of expectant mothers (Sebire et al. 2001; Ehrenberg et al. 2003; Watanabe et al. 2010; Ye et al. 2010). Therefore, in this study, we aimed to clarify the

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effect of the physique at the beginning of pregnancy of expectant mothers on the birth physique and sex of infants using a larger number of participants. To exclude the influence of gestational length, participants were limited to participants with full-term births. In addition to the physique of the infants, including the weight, height, head circumference and chest circumference, the Kaup index values were also examined. The results of this study suggest that mother's physique may have a stronger influence on the male infant's physique, compared to the girls, and that this effect may be more prominent in pluripara, compared to primiparas.

Subjects and Methods

Study subjects

This study was based on data obtained at health checkups for 18-month-old infants conducted in Hirakata, a city in the northern part of Osaka Prefecture, Japan, from April 2010 through September 2011. The population of Hirakata was 406,330 (July 1, 2012), the number of births in 2009 was 3,560 and the birth rate was 8.7%. The percentage of low birth weight infants was 9.9%. Fifty-two health checkups were conducted once a week during the study period. About 70 pairs of mothers and infants participated in each health checkup. There were 3,722 pairs of mothers and infants who participated in the study during this period, and the participation rate was 92.0%. We excluded foreign mothers, multiple births and mothers who declined participation. A total of 2,974 (79.9%) mothers were informed of the purpose of the study individually. A total of 1,398 (37.6%) mothers agreed to participate in this study. Of those 1,398 mothers, a total of 111 participants were excluded; 6 participants due to unknown weight or height of the mother, 22 participants due to a first physical examination past 20 weeks in the course of the pregnancy, 7 participants due to the mother being under the age of 20, 56 participants due to premature birth, and 20 participants due to incomplete data. The data from a total of 1,287 mothers (34.6%), with 621 boys and 666 girls were analyzed.

Study methods

Public health nurses and registered dietitians interviewed the mothers individually under anonymous conditions, and they transferred the required information from the maternity passbooks at a health checkup. It took about 3 minutes to conduct the interview and transfer the required information for each subject. The interviews were composed of the following 11 items: 8 items related to the characteristics of the mother (age at delivery, current weight and height, current smoking status and number of cigarettes smoked per day, smoking status and number of cigarettes smoked per day during pregnancy, passive smoking during pregnancy). Three items related to the offspring (sex, birth order, and history of diseases.) The data transfers were composed of the following 7 items: 3 items related to the mothers (weight, number of weeks for the first physical examination, and gestation length), and 4 items related to the offspring (birth weight, height, head circumference, and chest circumference).

Statistical analyses

The body mass index (BMI) of at beginning of pregnancy was calculated by dividing the weight obtained at the first physical examination of each participant by the square of the height (kg/m^2). The Japan Society for the Study of Obesity defined BMI as BMI < 18.5 kg/m^2 for the underweight group, BMI $\geq$ 18.5 kg/m^2 and < 25.0 kg/m^2 for the normal group and BMI $\geq$ 25.0 kg/m^2 for the overweight group. The Kaup index used for the size of the infant was calculated by dividing the birth weight by the square of the birth height ($g/cm^2 \times 10$).

We employed the mean and standard deviation of the quantitative data. The difference between the two groups was analyzed using the t test. We applied the χ^2 test for comparison between categories. We examined the association between the mother's status (gestational length, age at delivery, and physique) and the infant's physique. Partial correlation analysis was applied to study the association between the mother's BMI at the beginning of pregnancy and the infant's physique at birth, adjusted by gestational length and the mother's age at delivery. P values less than 0.05 were considered significant. The statistical software IBM SPSS Statistics for Windows Version 19.0 (IBM Japan Inc., Tokyo, Japan) was used for the analyses.

Ethical considerations

All of the participants in the study were informed of the purpose of the study. In addition, we confirmed their intention for participation in the study. Because the data were collected under completely anonymous conditions, this study does not require an ethical review at the author's affiliated university. The study protocol employed was approved by the Ethics Committee of Hirakata City Hospital (December 8, 2009). One of the authors was a member of that hospital.

Results

Table 1 shows the basic data for the maternal and infant characteristics stratified by sex. The rate of the primiparas was 51.2% for the boys and 44.4% for the girls, showing a significantly higher rate for the boys, compared with the girls (P = 0.009). There was significant difference in the gestation length (P = 0.023), although the difference was only 0.1 weeks (about 17 hours). Significant difference (P = 0.040) was shown in the rate of passive smoking during pregnancy: 43.3% for the mothers of boys and 37.5% for the mothers of girls. The boys showed a significantly higher birth weight (P < 0.001), height (P < 0.001), head circumference (P < 0.001) and chest circumference (P = 0.001), compared with the girls. However, no significant difference was detected in the Kaup index or the number of low birth weight infants between the two groups.

Table 2 shows the infant's birth size (birth height, weight, head and chest circumference and Kaup index) stratified by the mother's categories (birth order, smoking status and passive smoking) and the sex of the infant. The boys showed significantly lower head circumference (P = 0.008), chest circumference (P = 0.023) and Kaup index (P < 0.001) in the primipara group, compared with the pluripara group. On the other hand, there was no statistically significant difference in the infant's physique between the smoking or passive smoking groups during pregnancy. In the girls, except for the height, the four items showed statistically significantly lower values, the weight (P = 0.036),

Table 1. A comparison of the boys and girls in the physique and characteristics of beginning of pregnancy and theinfants at birth.

Number	Selected sample 1,287	Boys 621	Girls 666	P value
Mothers				
Height (cm)[a]	158.5 ± 5.4	158.7 ± 5.4	158.3 ± 5.3	0.291*
Weight (kg)[a]	52.7 ± 7.6	52.7 ± 7.9	52.6 ± 7.4	0.734*
BMI (kg/m^2)[a]	21.0 ± 2.8	20.9 ± 2.9	21.0 ± 2.7	0.872*
BMI category				0.467**
Underweight (BMI < 18.5) (%)	16.6	17.9	15.3	
Normal (BMI ≥ 18.5, < 25.0) (%)	75.6	74.4	76.7	
Overweight (BMI ≥ 25.0) (%)	7.8	7.7	8	
Primipara (%)	47.7	51.2	44.4	0.009**
Age at delivery (years)[a]	33.0 ± 4.5	33.0 ± 4.5	33.0 ± 4.5	0.770*
Age ≥ 35 (%)	38.1	37.5	38.6	0.368**
Gestational length (weeks)[a]	39.1 ± 1.2	39.0 ± 1.2	39.1 ± 1.2	0.023*
Smoking during pregnancy (%)	3.3	2.6	4.1	0.093**
Passive smoking during pregnancy (%)	40.3	43.3	37.5	0.040**
Infants				
Birth weight (g)[a]	3,059 ± 362	3,103 ± 359	3,018 ± 361	< 0.001*
Birth height (cm)[a]	48.9 ± 2.0	49.2 ± 1.9	48.6 ± 2.0	< 0.001*
Birth head circumference (cm)[a]	33.3 ± 1.3	33.5 ± 1.3	33.1 ± 1.3	< 0.001*
Birth chest circumference (cm)[a]	31.9 ± 1.6	32.0 ± 1.5	31.8 ± 1.6	0.001*
Kaup index (g/cm^2 × 10)[a]	12.8 ± 1.1	12.8 ± 1.1	12.8 ± 1.2	0.831*
Birth weight category				0.242**
Low (< 2,500 g) (%)	5.6	4.5	6.6	
Normal (≥ 2,500, < 4,000 g) (%)	94	95.2	92.9	
High (≥ 4,000 g) (%)	0.4	0.3	0.5	

[a]Mean ± SD.
*t test for differences between boys and girls.
**χ^2 test for differences between boys and girls.
BMI, body mass index.

head circumference (P = 0.001), chest circumference (P = 0.002) and Kaup index (P = 0.001) in the primipara group, compared with the pluripara group. On the other hand, there was no statistically significant difference in the infant’s physique between the smoking and passive smoking groups during pregnancy.

In the boys and girls, statistically significant difference was shown in the infant’s physique between the primipara and the pluripara groups. Therefore, we divided the expectant mothers into primipara and pluripara groups, and examined the relationship between physique at the beginning of the pregnancy of the expectant mothers and the body size of the infants at birth. Fig. 1A-D show the correlation charts of the mother’s BMI at the beginning of pregnancy and the infant’s birth Kaup index. These figures show the statistically significant relationship between the mother’s BMI at the beginning of pregnancy and the infant’s birth Kaup index, except for the girls in the primipara group.

Table 3 shows the correlation coefficient of the mother’s characteristics (BMI at the beginning of pregnancy, gestational length, age at delivery) and the physique of the infants at birth (weight, height, head circumference, chest circumference, and Kaup index) stratified by the sex of the infants.

In regard to the boys in the primipara group, there was statistically significant positive correlation between the BMI of the mothers and the weight (P = 0.016) and the Kaup index (P = 0.029, Fig. 1A). In the pluripara group, there was statistically significant positive correlation between the BMI of mothers and the weight (P = 0.030), the head circumference (P = 0.029) and the Kaup index (P = 0.037, Fig. 1B). In addition, there was a significant positive correlation between the mother’s age at delivery and the head circumference (P = 0.023).

In regard to the girls in the primipara group, there was no statistically significant correlation between the BMI of mothers and any of the items related to the physique of the infants (Fig. 1C). There was a statistically significant negative correlation between the mother’s age at delivery and the Kaup index (P = 0.029). On the other hand, in the pluripara group, there was statistically significant positive correlation between the BMI of mothers and the weight (P

Table 2. Infant's physical characteristics (mean ± SD) stratified by mother's status.

	Mothers	n	Birth weight (g)	P value*	Birth height (cm)	P value*	Birth head circumference (cm)	P value*	Birth chest circumference (cm)	P value*	Kaupindex	P value*
Boys (n = 621)	Parity											
	Primipara	318	3,079 ± 352	0.085	49.3 ± 1.9	0.213	33.4 ± 1.3	0.008	31.9 ± 1.5	0.023	12.6 ± 1.0	< 0.001
	Pluripara	303	3,129 ± 365		49.1 ± 1.9		33.6 ± 1.2		32.2 ± 1.6		12.9 ± 1.1	
	Smoking during pregnancy											
	Yes	16	3,062 ± 307	0.643	49.5 ± 2.2	0.63	33.6 ± 1.0	0.701	32.2 ± 1.3	0.746	12.5 ± 1.3	0.372
	No	604	3,105 ± 361		49.2 ± 1.9		33.5 ± 1.3		32.0 ± 1.5		12.8 ± 1.1	
	Passive smoking during pregnancy											
	Yes	267	3,121 ± 347	0.252	49.3 ± 1.8	0.63	33.5 ± 1.2	0.728	32.1 ± 1.6	0.427	12.8 ± 1.1	0.206
	No	350	3,087 ± 367		49.2 ± 2.0		33.5 ± 1.3		32.0 ± 1.5		12.7 ± 1.1	
Girls (n = 666)	Parity											
	Primipara	296	2,985 ± 356	0.036	48.6 ± 1.9	0.523	32.9 ± 1.3	0.001	31.5 ± 1.6	0.002	12.6 ± 1.1	0.001
	Pluripara	370	3,044 ± 364		48.5 ± 2.0		33.3 ± 1.2		31.9 ± 1.6		12.9 ± 1.2	
	Smoking during pregnancy											
	Yes	27	3,018 ± 443	0.987	48.4 ± 1.9	0.588	32.9 ± 1.2	0.459	31.6 ± 1.8	0.574	12.8 ± 1.3	0.718
	No	638	3,017 ± 357		48.6 ± 2.0		33.1 ± 1.3		31.8 ± 1.6		12.8 ± 1.1	
	Passive smoking during pregnancy											
	Yes	247	3,040 ± 368	0.148	48.7 ± 1.9	0.449	33.1 ± 1.2	0.775	31.9 ± 1.6	0.151	12.8 ± 1.2	0.218
	No	412	2,998 ± 355		48.5 ± 2.0		33.1 ± 1.3		31.7 ± 1.6		12.7 ± 1.1	

*t test.

Table 3. Relationship between mother's status and infant's physique at birth.

			Birth weight (g)		Birth height (cm)		Birth head circumference (cm)		Birth chest circumference (cm)		Kaup index	
		Mothers	correlation coefficient	P value*	correlation coefficient	P value*	correlation coefficient	P value*	correlation coefficient	P value*	correlation coefficient	P value*
Boys (n = 621)	Primipara	BMI (kg/m^2)	0.135	0.016	0.076	0.178	0.073	0.195	0.094	0.095	0.122	0.029
		Gestational length (weeks)	0.408	< 0.001	0.352	< 0.001	0.32	< 0.001	0.385	< 0.001	0.248	< 0.001
		Age at delivery (years)	−0.036	0.523	−0.014	0.803	0.084	0.138	−0.062	0.271	−0.042	0.456
	Pluripara	BMI (kg/m^2)	0.124	0.03	0.059	0.31	0.126	0.029	0.092	0.111	0.12	0.037
		Gestational length (weeks)	0.424	< 0.001	0.348	< 0.001	0.252	< 0.001	0.355	< 0.001	0.279	< 0.001
		Age at delivery (years)	0.057	0.323	0.096	0.094	0.13	0.023	−0.019	0.741	−0.014	0.803
Girls (n = 666)	Primipara	BMI (kg/m^2)	0.041	0.485	0.029	0.621	0.075	0.20	0.021	0.612	0.026	0.659
		Gestational length (weeks)	0.472	< 0.001	0.384	< 0.001	0.277	< 0.001	0.445	< 0.001	0.312	< 0.001
		Age at delivery (years)	−0.059	0.308	0.056	0.339	0.025	0.664	−0.039	0.506	−0.127	0.029
	Pluripara	BMI (kg/m^2)	0.116	0.026	0.047	0.369	0.059	0.26	0.11	0.035	0.106	0.042
		Gestational length (weeks)	0.465	< 0.001	0.37	< 0.001	0.138	0.008	0.371	< 0.001	0.271	< 0.001
		Age at delivery (years)	−0.045	0.386	−0.009	0.861	−0.068	0.193	−0.023	0.659	−0.052	0.318

*Pearson product-moment correlation coefficient.
BMI, body mass index.

= 0.026), the chest circumference (P = 0.035) and the Kaup index (P = 0.042, Fig. 1D). Regardless of the sex, in both the primipara and the pluripara groups, there was statistically significant positive correlation between the gestational length and all of the items related to the physique of the infants.

Our results showed that the gestational length and the age at delivery influenced the association between the mothers' physique and the infants' physique. Table 4 shows the correlation coefficient of the BMI at the beginning of the pregnancy of the expectant mothers and the physique for infants at birth, adjusted by the gestational length and the mother's age at delivery. In regard to the boys in the primipara group, there was statistically significant positive correlation between the BMI of the mothers and the weight (P = 0.025) and the Kaup index (P = 0.035). On the other hand, in the pluripara group, the significant positive correlation was found in the weight (P = 0.006), the head

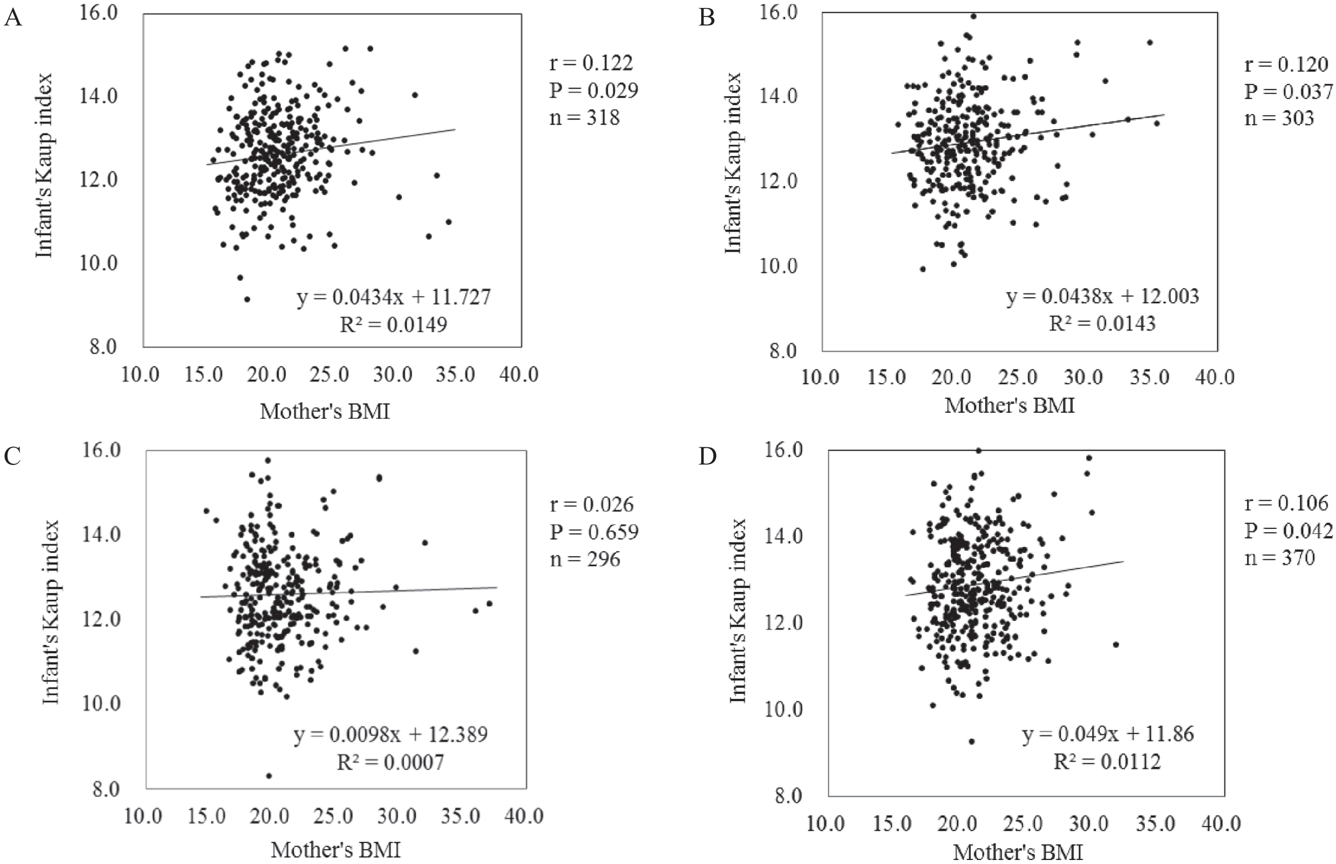

Fig. 1. Relationship between mother's BMI at the beginning of pregnancy and infant's Kaup index at birth.
A. The correlation of the mother's BMI and the infant's Kaup index (318 boys born to the primipara). Note the statistically significant relationship. B. The correlation of the mother's BMI and the Kaup index (303 boys born to the pluripara). Note the statistically significant relationship. C. The relationship of the mother's BMI and the infant's Kaup index (296 girls born to the primipara). No statistically significant relationship. D. The relationship of the mother's BMI and the infant's Kaup index (370 girls born to the pluripara). Note the statistically significant relationship.

Table 4. Relationship between mother's BMI at the beginning pregnancy and infant's physique at birth.

		Birth weight (g)		Birth height (cm)		Birth chest circumference (cm)		Birth head circumference (cm)		Kaup index	
	Mothers	correlation coefficient	P value*	correlation coefficient	P value*	correlation coefficient	P value*	correlation coefficient	P value*	correlation coefficient	P value*
Boys (n = 621)	Primipara	0.126	0.025	0.059	0.30	0.042	0.461	0.071	0.207	0.119	0.035
	Pluripara	0.159	0.006	0.066	0.253	0.122	0.035	0.127	0.028	0.15	0.009
Girls (n = 666)	Primipara	0.045	0.44	0.022	0.708	0.073	0.212	0.031	0.596	0.034	0.565
	Pluripara	0.115	0.027	0.037	0.479	0.058	0.267	0.106	0.043	0.103	0.048

*partial correlation coefficient.
Control variables; gestational length and mother's age at delivery.
BMI, body mass index.

circumference (P = 0.035), the chest circumference (P = 0.028) and the Kaup index (P = 0.009). In case of the girls in the primipara group, there was no statistically significant correlation between the BMI of the mothers and any of the items related to the physique of the infants. In contrast, in the pluripara group, significant positive correlation was demonstrated for the weight (P = 0.027), the chest circumference (P = 0.043) and the Kaup index (P = 0.048).

Discussion

Recently, the average birth weight has decreased (National growth survey on preschool children in Japan in 2010) (Ministry of Health, Labour and Welfare 2010a). Several studies have suggested that leanness and smoking during the age period in which childbearing is possible, as well as an increase in maternal delivery at a later age are responsible for the decrease in the average birth weight (Takimoto et al. 2005; Murakami et al. 2005; Noguchi 2008).

In this study, we examined the physique of infants at birth that may be related to the characteristics of the expectant mothers. As a result, we found significant association between the BMI at the beginning of the pregnancy of the expectant mothers and the physique of the infants at birth. No significant difference was observed in the size of infants stratified by smoking during pregnancy. We considered that the low number of smokers (3.3%) might have influenced the results. Furthermore, we cannot ignore the possibility that there was unreported smoking, because the study was based on interviews. The size of the infants in the primipara group was smaller than that of the pluripara group. Takano and Fujimura (1973) reported that first infants showed the smallest size at birth, which was in agreement with the results of the present study.

In order to explore the influence of birth order, we divided the expectant mothers into primipara and pluripara groups, and examined the relationship between the BMI of the expectant mothers at the beginning of the pregnancy and the relationship with the size of the infants at birth, adjusted by gestational length and the mother's age at delivery adjusted by sex and birth order. In animal experiments, Chow and Lee (1964) reported that when pregnant rats were fed an amount of feed reduced by 25%, the rats showed lower body weight values, compared with the control group up to 40 weeks of age from birth, and the difference was clearly shown in males, compared with the female pups. On the other hand, Hashimoto et al. (2004) reported that high blood pressure due to protein restriction in pregnant rats was more likely to appear in females than in males. Suzuki et al. (2011) examined the association between smoking during pregnancy and the BMI of infants. As a result, no gender difference was shown, but their results showed that the BMI rose for boys, especially after the age of three. Harada et al. (2012) examined the association between birth weight and the physique in adulthood adjusted by sex in health screening examinees. As a result, the adult waist-to-height ratio was only higher in the low birth weight group in non-obese women. Thus, the health status of female adults may be influenced by their birth weight.

In this study, in regard to the boys in the primipara group, there was statistically significant positive correlation between the BMI of the mothers and the birth weight and the Kaup index. However, in the girls, there was no statistically significant correlation between the BMI of the mothers and any of the items related to the physique of the infants. In regard to the boys in the pluripara group, there was statistically significant positive correlation between the BMI of the mothers at the beginning of pregnancy and the physique of the infants: the weight, the head circumference, the chest circumference and the Kaup index. In the girls, there was statistically significant positive correlation between the BMI of the mothers and the weight, the chest circumference and the Kaup index of the infants. That is, in case of the boys, the pluripara group had an increased number of items showing a significant correlation, compared to the primipara group. In the girls, there was no item that shows significant correlation in the primipara group, but in the pluripara group, significant correlation was observed for three items. Thus, there was sex-related difference in the effect of the BMI of expectant mothers at the beginning of pregnancy on the physique of infants, suggesting that the influence was stronger in boys than girls, and also stronger in the pluripara than the primiparas.

In the boys born to the pluripara, there was a statistically significant positive correlation between the BMI at the beginning of the pregnancy of the mothers and the head circumference of the infants. Particularly, several studies (Barker et al. 1993; Risnes et al. 2009) have indicated that a short head circumference at birth was associated with an increase in the risk of death due to heart disease later in the life. A study conducted by Emond et al. (2006) showed an independent correlation between head circumference at birth and the intelligence quotient (IQ) at the age of 6 years, even after adjustments for social background, such as the education of the mother. Considering that a low birth weight could lead not only to a higher risk of diseases in the latter life of the infants, but also the possibility of low intelligence of the infant later in life, it is important to reduce the number of low birth weight infants.

There were several limitations in this study, as follows. Because public health nurses and registered dietitians interviewed the mothers individually and transferred information from maternity passbooks, the response rate of this study was 37.6%, which was relatively low. In addition, we did not examine all of the factors that could have affected the physique of the infants studied, such as nutrition during pregnancy and the gestational weight changes. However, we considered that it was possible to analyze the relationship between the physique of expectant mothers and the birth size of infants, because we obtained answers from 1,287 participants who gave birth at full-term.

In this study, the average birth weight was 3,103 ± 359 g in the boys and 3,018 ± 361 g in the girls. According to the National growth survey on preschool children in Japan in 2010 published by the Ministry of Health, Labour and Welfare (2010a) in Japan, the average infant birth weight was 2.98 kg in boys, and 2.91 kg in girls. These values were also almost the same as those for the participants of this study. The average age of the 1,287 participants in this study was 33.0 ± 4.5 years and the age of childbirth was 21-46 years. According to the statistics on birth published in 2010 by the Ministry of Health, Labour and Welfare (2010b) in Japan (Specified report of vital statistics in Japan in 2010), the average age of childbirth was 31.0 years. The participants were a population with a slightly higher average age at childbirth. The average BMI at the beginning of pregnancy was 21.0 ± 2.8, and the rate of leanness was 16.6% in the participants. According to data published by the National Nutrition and Health Survey in Japan in 2010 (National Institute of Health and Nutrition 2012), the average BMI was 21.6, and the rate of leanness was 14.4% in women for thirty generations. These values were almost the same as those for the participants of this study. Therefore, we considered that the subject population was representative of the population of average Japanese women during pregnancy, and thus appropriate for the purpose of the study.

Several studies have been conducted on the relationship between the physique in expectant mothers and the birth weight of infants, but few have examined the effect of the sex of the infants (Sebire et al. 2001; Ehrenberg et al. 2003; Watanabe et al. 2010; Ye et al. 2010). Our study showed that there was sex difference in the effect of the BMI of expectant mothers at the beginning of the pregnancy on the physique of the infants, suggesting that the influence might be stronger for boys than girls, and also stronger in the pluripara group than in the primipara group. In the future, studies should be conducted to elucidate the mechanisms related to those sex differences.

In conclusion, analyzing the effect of the physique of expectant mothers on the size of infants, adjusted by the sex of the offspring, we have concluded that the influence of the mother's physique is stronger for boys than girls, and also stronger in pluripara, compared with primiparas.

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Conflict of Interest

The authors declare no conflict of interest.

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