Analysis of Factors Affecting Birthweight, Birth Length and Head Circumference: Study of Japanese Triplets

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The aims of this study were to identify factors associated with birthweight, birth length and head circumference for triplets, and analyze these body size parameters at birth, especially head circumference, according to gestational age. The subjects of this study were 370 mothers and their 1109 triplet children (excluding one stillborn infant) who were born between 1978 and 2002. The gestational age proved to be the strongest contributing factor to birthweight, birth length and head circumference of the triplets. Moreover, sex was a significant factor affecting birthweight, birth length and head circumference. Male neonates had a higher birthweight, longer birth length and greater head circumference than female neonates. Birth order in triplets also had a significant effect on birthweight and head circumference. Lower birth-order neonates had a higher birthweight and greater head circumference. An effect of maternal pregravid body mass index (BMI) on both birthweight and birth length was observed. The birthweights of triplets born to women whose pregravid BMIs were more than 26.0 kg/m^2 weighed an average of 150 g more than those of triplets born to women whose pregravid BMIs were less than 19.8 kg/m^2, and the birth length of triplets born to women whose pregravid BMIs were more than 26.0 kg/m^2 averaged 1.5 cm longer than those of triplets born to women whose pregravid BMIs were less than 19.8 kg/m^2. Concerning head circumference, the median head circumference of male neonates was approximately 0.5 cm longer than female neonates. Compared to singleton neonates, the median head circumference of triplets was almost the same.

In Japan, as in other developed countries, multiple births have been increasing as a result of infertility treatment. Especially, the triplet rate has rapidly increased: 4.2 fold between 1974 and 2001 (Imaizumi, 2003). The perinatal mortality rate of triplets is much higher than that of twins or singletons (Imaizumi, 1994). As birthweight is the strongest indicator of the risk of perinatal death, birthweight norms are important both for clinical practices and epidemiologic studies (Glinianaia et al., 2000).

Meanwhile, it was often indicated that the intrauterine growth of multiple birth neonates showed asymmetrical hypotrophy and that not only birthweight, but also other measurements should be taken into account (Hennequin et al., 1999; Winter et al., 1994). Kato (2004) and Kato and Uchiyama (2005) analyzed the birthweight and birth length of multiple birth neonates, including triplets, using data from corresponding birth certificates, and these data are probably the most reliable in Japan. However, there have been few studies on the head circumference of triplets in Japan. Further, there is a limitation when analyzing factors affecting birthweight, birth length and head circumference for triplets, since the database of birth certificates does not contain detailed obstetrical records. The aims of this study were therefore to identify factors associated with birthweight, birth length and head circumference for triplets, and analyze these body size parameters at birth, especially the head circumference of triplets, according to gestational week.

Subjects and Methods

The subjects of this study were recruited from the Okayama University Higher Order Multiple Births Registry (Yokoyama, 2002; Yokoyama, 2003; Yokoyama et al., 1995), which consisted of 569 mothers with triplets who were born between 1978 and 2002. Mothers and their triplets were enrolled from several other sources, such as various Japanese Mother's Organization for Higher Order Multiple Births and referrals from public health nurses.

Data were collected through a mailed questionnaire. For these births, data on birthweight, birth

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Table 1

Major Characteristics of Subjects

Sex	Male	550 (49.6%)
	Female	523 (47.2%)
	Unknown	36 (3.2%)
Maternal age of delivery	Mean ± standard deviation	30.7 ± 3.62
	Range	20–42
Infertility treatment	Not used	210 (18.9%)
	Used	875 (78.9%)
	Unknown	24 (2.2%)
Maternal pregravid body mass index	Mean ± standard deviation	20.8 ± 2.41
	Range	15.4–32.4
Gestational age (weeks)	Mean ± standard deviation	33.5 ± 2.64
	Range	25–38
Parity	0	865 (78.0%)
	≥ 1	240 (21.6%)
	Unknown	4 (0.4%)
Year of delivery	1978–1989	54 (4.9%)
	1990–1994	288 (26.0%)
	1995–1999	587 (52.9%)
	2000–2003	180 (16.2%)

Table 2

Birthweight, Birth Length and Head Circumference of Triplets

		Birthweight (g)			Birth length (cm)			Head circumference (cm)		
		n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Sex	Male	546	1735.0	440.8	482	41.9	3.76**	455	30.1	2.49*
	Female	520	1692.2	421.5	464	41.2	3.50	428	29.8	2.26
Parity	Multipara	240	1805.5	461.0***	209	42.1	3.73*	205	30.1	2.40
	Primipara	858	1689.9	418.3	770	41.4	3.58	713	30.0	2.38
Birth order	First-born	368	1772.2	422.0***	326	41.7	3.44	305	30.3	2.33**
	Second-born	368	1713.7	439.2	328	41.6	3.66	302	29.9	2.38
	Third-born	366	1656.8	421.7	328	41.3	3.75	312	29.7	2.40
Maternal pregravid BMI	26.0 <	33	1834.7	447.3**	31	42.7	4.02**	31	30.5	2.17
	19.8–26.0	639	1743.4	432.0	565	41.8	3.62	530	30.0	2.34
	< 19.8	373	1661.1	429.5	336	41.1	3.64	315	29.9	2.49
Infertility treatment	Not used	210	1744.3	440.5	181	41.6	3.63	178	30.0	2.31
	Used	868	1705.5	431.1	780	41.5	3.66	720	30.0	2.42
Maternal age at triplet birth	< 25	30	1531.7	325.1*	22	40.5	2.45	23	29.6	1.74
	25–29	398	1751.3	434.2	347	41.7	3.72	328	30.1	2.28
	30–34	491	1699.4	437.6	447	41.4	3.70	413	29.9	2.54
	35 ≤	180	1696.2	404.4	163	41.8	3.28	152	30.0	2.25
Year of delivery	1978–1989	54	1957.9	319.8***	48	43.0	2.17***	41	30.9	1.30**
	1990–1994	285	1772.8	446.8	228	42.3	3.75	224	30.2	2.30
	1995–1999	583	1691.8	410.9	538	41.3	3.44	487	29.9	2.28
	2000–2003	180	1621.6	455.2	168	40.8	4.03	167	29.6	2.84

Note: *M* = mean; *SD* = standard deviation.

* $p < .05$, ** $p < .01$, *** $p < .001$.

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Table 3

Results of Multiple Regression Analysis of Factors Associated With Birthweight, Birth Length and Head Circumference (Stepwise Method)

Dependent variable	Independent variable	Beta	*p*	Multiple *R*	Adjusted R^2
Birthweight	Gestational age	.810	$p < .001$	.825	.679
	Birth order in triplets	–.113	$p < .001$		
	Maternal pregravid BMI	.067	$p < .001$		
	Sex	–.063	$p < .001$		
Birth length	Gestational age	.779	$p < .001$	.789	.622
	Sex	–.112	$p < .001$		
	Maternal pregravid BMI	.054	$p < .05$		
Head circumference	Gestational age	.798	$p < .001$	.806	.648
	Birth order in triplets	–.097	$p < .001$		
	Sex	–.089	$p < .01$		

length, head circumference, gestational age, sex, parity, maternal age at delivery, year of delivery, maternal pregravid weight and maternal height were obtained from records in the Maternal and Child Health Handbooks. This handbook was established by the Maternal and Child Health Law in Japan and is provided by the governor after a report of pregnancy. The purpose of this handbook is the maintenance of maternal and child health: medical examinations during pregnancy, the condition of the newborn, the progress of infant growth, and periodic medical examinations for the infant and vaccinations recorded by obstetricians or pediatricians. In addition to the above data, information on infertility treatment was obtained.

The means and standard deviations of birthweight, birth length and head circumference for triplets were calculated according to sex, parity, birth order, maternal pregravid body mass index (BMI, kg/m^2), infertility treatment, maternal age at triplet birth and year of delivery. The significance of differences between mean values was tested using the *t* test where the comparison was between two groups, and using ANOVA where the comparison was among more than three groups.

The factors affecting birthweight, birth length and head circumference were confirmed by stepwise regression analysis, with a threshold significance level of .05. The independent variables were gestational age, sex, parity, birth order of triplets, maternal pregravid BMI, infertility treatment, maternal age at triplet birth and year of delivery. For qualitative variables, the following codes were used: sex, male = 0, female = 1; birth order, first-born = 0, second-born = 1, third-born = 2; parity, primipara = 0, multipara = 1; infertility treatment, not used = 0, used = 1.

The selected percentiles (10th, 50th and 90th) of birthweight, birth length and head circumference by gestational age and sex were calculated. Smoothing of growth curves was performed by cubic polynominal functions. The 50th percentile curve of birthweight for the present subjects was compared with previously reported norms for triplets (Kato, 2004) and the 50th percentile curve of head circumference for the present subjects was compared with norms for singletons in Japan (Ogawa et al., 1998). The SPSS statistical package (version 11.5 for Windows) was used for statistical analyses.

Results

The subjects were 370 mothers and their 1109 triplet children (excluding one stillborn infant). The response rate was 65.0%. Mothers in the present study consented to the aim of the study and were told that data would be used only for this study.

Table 1 summarizes the characteristics of the subjects. The mean gestational age at birth for triplets delivered between 1978 and 1989 was 35.5 ± 2.13 weeks, for triplets delivered between 1990 and 1994, 34.0 ± 2.68 weeks, for triplets delivered between 1995 and 1999, 33.2 ± 2.44 weeks, and for triplets delivered between 2000 and 2003, 33.0 ± 2.95 weeks. Gestational age at birth significantly differed by year of delivery ($p < .001$).

Table 2 shows the mean birthweight, birth length and head circumference analyzed according to sex, parity, birth order, maternal pregravid BMI, infertility treatment, maternal age at triplet birth and years of delivery. Male, multiparous, lower birth order neonates and neonates born to women whose pregravid BMIs were higher, had a higher birthweight and longer birth length. These differences were statistically significant, except for the difference between birth order and birth length. Male and lower birth order neonates had significantly longer head circumferences. Neonates born to women aged 25 to 29 years had a higher birthweight than neonates born to women older or younger than that. Moreover,

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Table 4

Birthweight, Birth Length and Head Circumference of Triplets by Gestational Age and Sex

	Gestational age (week)	Male				Female			
			Percentiles				Percentiles		
		n	10th	50th	90th	*n*	10th	50th	90th
Birthweight (g)	25–28	33	671.8	963.0	1278.6	27	752.8	888.0	1118.4
	29	19	965.3	1262.4	1450.6	14	866.3	1192.9	1418.1
	30	34	1040.9	1360.2	1588.5	38	953.6	1290.6	1526.9
	31	45	1122.4	1465.5	1728.9	33	1049.6	1396.4	1644.1
	32	55	1210.3	1579.1	1871.9	49	1155.4	1510.9	1770.2
	33	78	1305.2	1701.4	2017.5	81	1271.7	1634.8	1906.0
	34	90	1407.4	1833.2	2165.6	116	1399.8	1768.8	2052.3
	35	83	1517.6	1975.2	2316.2	62	1540.8	1913.8	2209.7
	36	54	1636.5	2128.2	2469.4	39	1696.0	2070.6	2379.3
	37	29	1764.7	2293.0	2625.1	37	1866.9	2240.4	2561.9
	38	17	1902.9	2470.6	2783.5	13	2054.9	2424.0	2758.4
Birth length (cm)	25–28	27	31.0	34.8	36.1	23	30.0	33.5	39.7
	29	19	33.6	38.3	40.6	12	33.4	37.2	39.7
	30	29	34.7	39.1	41.5	31	34.4	38.1	40.7
	31	35	35.7	40.0	42.5	29	35.4	39.0	41.6
	32	50	36.8	40.9	43.5	42	36.4	39.9	42.6
	33	75	37.9	41.9	44.6	79	37.5	40.9	43.6
	34	81	39.1	42.8	45.6	102	38.6	41.8	44.7
	35	77	40.3	43.8	46.7	59	39.8	42.8	45.7
	36	47	41.5	44.8	47.8	33	40.9	43.9	46.8
	37	21	42.8	45.8	49.0	33	42.1	44.9	47.9
	38	16	44.1	46.8	50.2	13	43.4	46.0	49.0
Head circumference (cm)	25–28	27	22.2	24.5	26.5	18	21.5	24.7	26.5
	29	17	24.3	27.0	28.9	8	23.8	25.6	28.1
	30	29	25.5	27.9	29.7	32	25.0	26.9	29.1
	31	38	26.6	28.8	30.5	29	26.0	28.0	30.0
	32	41	27.6	29.6	31.2	34	27.0	29.0	30.8
	33	70	28.5	30.4	31.9	74	27.8	29.9	31.6
	34	74	29.3	31.1	32.5	98	28.5	30.7	32.2
	35	74	29.9	31.6	33.0	55	29.1	31.3	32.8
	36	47	30.5	32.1	33.5	31	29.7	31.8	33.2
	37	21	30.9	32.6	34.0	31	30.1	32.2	33.6
	38	15	31.2	32.9	34.5	10	30.3	32.4	33.9

birthweight, birth length and head circumference significantly differed by year of delivery.

Table 3 shows the results of stepwise regression analysis on birthweight, birth length and head circumference with associated factors as independent variables. The contribution of gestational age was the strongest in terms of birthweight, birth length and head circumference. Sex also significantly affected birthweight, birth length and head circumference. Parity, infertility treatment, maternal age at triplet birth and year of delivery did not meet the .05 significance level for entry into the model.

The selected percentiles of birthweight, birth length and head circumference, as calculated in our study, are presented in Table 4. As the sample size below 28 weeks was small, smoothing was performed only for 29 to 38 weeks of gestation. The 50th percentile curve of birthweight compared with

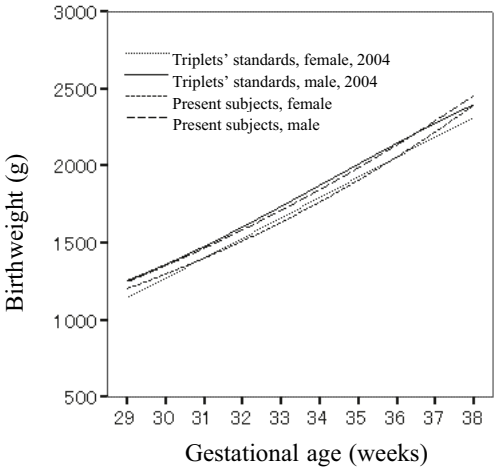

Figure 1

Median birthweight for triplets compared tripets' standards.

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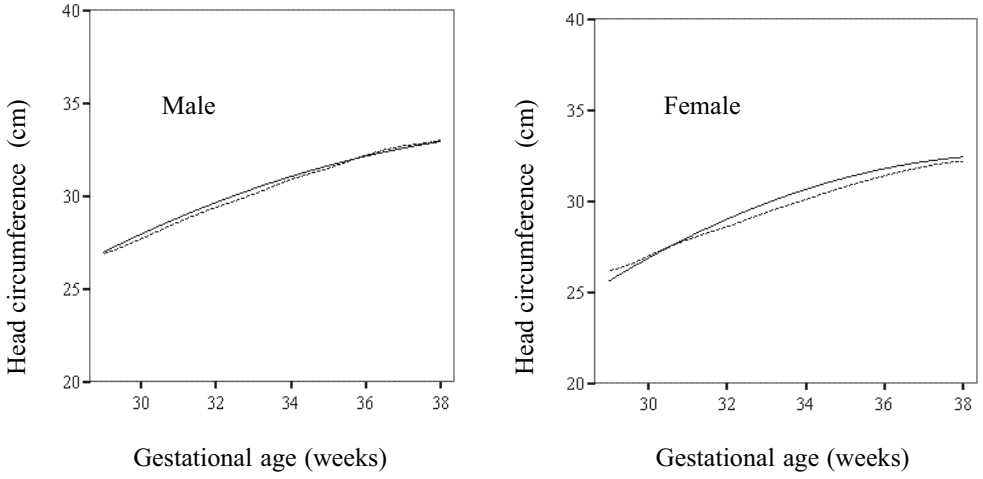

Figure 2

50th percentiles for triplets compared with singletons' standards. (---) singletons', (—) triplets.

the standards for triplets (Kato, 2004) is shown in Figure 1. The figure for the 50th percentile curve of the present subjects mostly runs near the standards for triplets. The 50th percentile curve of head circumference compared with the standards for singletons (Ogawa et al., 1998) is shown in Figure 2. Head circumference for triplets was almost the same as, or slightly larger than, that of singletons. The 50th percentile of head circumference was approximately 0.5 cm longer in male neonates than in females (Figure 3).

Discussion

The sample size of this study was not as large as triplet studies performed in the United States (Blickstein et al., 2004; Elster et al., 1991). In Japan, it is extremely difficult to simultaneously obtain obstetrical records and body size parameters at birth on a large number of triplets, as there is no population-based triplet registry. Only two main sources of data on triplets in Japan have been established. First, a vital statistics birth record is available for birthweight and birth length information. However, there is no head circumference or chest circumference information in the vital statistics. Second, data from hospitals have been used in the field of obstetrics, mainly in managing high-risk pregnancies. Although this method is relatively easy to use, it may allow large selection biases to occur. To bridge the gap between vital statistics and hospital data, the authors have been constructing a triplet and higher-order multiple birth registry. The present data were collected from the subjects of this registry. This data set is larger and less biased than hospital data, and the information is more detailed than the vital statistics.

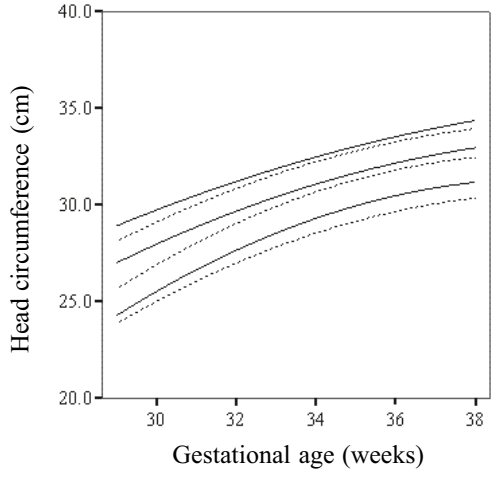

Figure 3

Head circumference percentile curves of triplets. (---) female, (—) male. The three lines for each category correspond to the 10th, 50th and 90th percentiles.

The median birthweight curve for the present subjects was similar to those reported by Kato (2004), although the birthweight of the present subjects was slightly higher than that reported by Kato (2004) at 38 weeks of gestation. Therefore, it was considered that the present data closely reflected the characteristics of the general triplet population, although there was selection bias because this study was not a population-based survey.

Buckler and Green (1994) reported that from 37 weeks' gestation onwards the mean head circumference of twins starts to decline compared with that of singletons, but the difference was only 5 mm. In addition, it was reported that the head circumference of Japanese twins was almost the same as, or larger than, the standard for Japanese singletons (Ooki & Yokoyama, 2003). The median head circumference curve for the present triplets was almost the same as that of singletons (Ogawa et al., 1998). Therefore, the deficit of head circumference for triplets is very small compared with that of singletons. Moreover, the

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median head circumference of male neonates was approximately 0.5 cm longer than female neonates. This result is consistent with the result for twins reported by Buckler and Green (1994).

Concerning factors associated with birthweight, birth length and head circumference in triplets, gestational age proved to be the strongest contributing factor. Moreover, sex was a significant factor affecting birthweight, birth length and head circumference. Male neonates had a higher birthweight, longer birth length and longer head circumference than female neonates. These results are in accordance with previous reports on twins (Blickstein et al., 1995; Buckler & Green, 1994; Ooki & Yokoyama, 2003) and singletons (Arbuckle et al., 1993). These data indicate a tendency for male neonates to be heavier and larger than female neonates, regardless of the numbers of fetuses.

In this study, birth order in triplets had significant effects on birthweight and head circumference: lower birth order neonates had a higher birthweight and longer head circumference. Orlebeke et al. (1993) indicated that first-born triplets weighed more than triplets born later. Our results are consistent with those reported by Orlebeke et al. (1993).

Meanwhile, Elster et al. (1991) reported that the birthweight of triplets increased with increasing maternal height and weight. In the present study, an effect of maternal pregravid BMI on both birthweight and birth length was observed. Birthweights of triplets born to women whose pregravid BMIs were more than 26.0 kg/m^2 weighed an average of 150 g more than those of triplets born to women whose pregravid BMIs were less than 19.8 kg/m^2, and the birth lengths of triplets born to women whose pregravid BMIs were more than 26.0 kg/m^2 averaged 1.5 cm longer than those of triplets born to women whose pregravid BMIs were less than 19.8 kg/m^2. These results indicate that maternal pregravid physique is a significant factor affecting both the birthweight and birth length of triplets.

Several studies of twins (Blickstein et al., 1995; Ooki & Yokoyama, 2003) have reported an effect of parity on birthweight and birth length, and infants born primipara seem to be smaller than those born multipara. In this study, regression analysis showed that parity did not affect the birthweight or birth length of triplets.

Mean birthweight and mean birth length for triplets showed a tendency to decrease year by year. Moreover, mean gestational age at birth also decreased year by year. Therefore, lower birthweight and birth length might be linked to lower gestational age. The reason for decreasing gestational age year by year should be investigated in the future.

Data on zygosity, smoking and drinking are lacking in this study, and it has been suggested that these factors are associated with birthweight and birth length (Ooki & Yokoyama, 2004; Vogazianos et al., 2005). These factors will be investigated in a future study. There is no physical growth chart after birth for triplets, despite the rapid increase in triplets and the increasing need to provide appropriate information to parents and nursing staff. We will next investigate the physical growth of triplets after birth.

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