Growth Charts of Length and Height from Birth to Six Years of Age in Japanese Triplets

Yoshie Yokoyama,[1] Masako Sugimoto,[2] Karri Silventoinen,[3] Janne Pitkäniemi,[3] and Jaakko Kaprio[3,4]

[1] *Department of Community Health Nursing, Osaka City University, Osaka, Japan*
[2] *Nishinomiya City Public Health Center, Nishinomiya, Japan*
[3] *Department of Public Health, University of Helsinki, Helsinki, Finland*
[4] *Department of Mental Health and Alcohol Research, National Public Health Institute, Helsinki, Finland*

We analyzed the characteristics associated with the growth in length and height of Japanese triplets from birth to 6 years of age and present the growth charts for them. The study included 354 mothers and their 1,061 triplet children, who were born between 1978 and 2006. Data were collected through a mailed questionnaire sent to the mothers asking for information recorded in medical records. For these births, data on triplets' length and height growth, gestational age, sex, parity, and maternal age at delivery were obtained from records in the Maternal and Child Health Handbooks, which is provided by the authorities after a report of pregnancy. Birth length showed the strongest contribution to height of triplets from 1 to 6 years of age. In addition, birthweight was also a significant contributing factor to height from 1 to 3 years of age. Compared to the 50th percentile of the growth standard for the general population of Japan, the length and height deficit of the triplets was approximately 15% at birth (male, –7.0 cm; female, –7.0 cm), decreased within the first year of age, and fluctuated between 2 and 5% until 6 years of age (male, –3.7 cm; female, –3.3 cm). In conclusion, triplets have lower birth length and subsequent height than singletons. In spite of the catch-up growth during the first year of life, they are behind singletons even in mid-childhood. This study provides height growth curves for triplets.

Keywords: triplet, length, height, growth, birthweight gestational age, sex

Since the introduction of assisted reproductive technology, the rate of multiple births has increased in Japan, as it has in all industrialized countries. Especially the triplet rate has rapidly increased: 4.2-fold from the year 1974 to 2001 (Imaizumi, 2003). It is well known that the growth patterns of twins or triplets during pregnancy are very different from those of singletons. Studies on the birthweight and birth length of twins or triplets have been conducted in many countries (Arbuckle et al., 1993; Buckler & Green, 1994; Glinianaia et al., 2000; Kato, 2005; Min et al., 2000; Min et al., 2004; Orlebeke et al., 1993). However, there are few previous studies on the postnatal growth, especially length/height growth, of triplets in the world, while a number of studies on the postnatal growth of twins have been conducted (Alfieri et al., 1987; Akerman & Fischbein, 1992; Luke et al., 1995; Ooki & Yokoyama, 2004; Philip 1981; Silventoinen et al., 2008; Wilson, 1974; Wilson, 1976; Wilson, 1979).

Most of triplets are born prematurely and have subsequently lower birthweight compared to singletons and twins (Glinianaia et al., 2000; Kato, 2004). Luke et al. (2006) reported a study comparing the early childhood growth of US twins versus triplets through 18 months of age and demonstrated that triplets have slower postnatal growth and more residual stunting. The physical growth of triplets after 18 months of age may remain behind that of singletons, but this has not been demonstrated earlier. Moreover, many factors that affect body size after birth, such as the perinatal medical system, body size at birth, and maternal and paternal body size, differ significantly between Asian and Western countries. It is essential to obtain objective growth data based on a large sample of Asian triplets. The purpose of this study was to analyze the characteristics of the length/height growth of triplets from birth to 6 years of age and to present the length/height growth charts of Japanese triplets.

Subjects and Methods

The subjects of this study were recruited from the Osaka City University Higher Order Multiple Births Registry (Yokoyama et al., 1995; Yokoyama, 2002; Yokoyama et al., 2005), which consisted of 578 mothers with triplets who were born between 1978 and 2006. Mothers and their triplets were enrolled also from several other sources, such as various Japanese

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Address for correspondence: Yoshie Yokoyama, Department of Community Health Nursing, Osaka City University, 1-5-17 Asahi-machi, Abeno-ku, Osaka 545-0051, Japan. E-mail: yyokoyama@nurs.osaka-cu.ac.jp

Mother's Organizations for Higher Order Multiple Births and referrals from public health nurses.

Data were collected through a mailed questionnaire sent to the mothers asking for information recorded in medical records. For these births, data on triplets' length/height growth, gestational age, sex, parity, and maternal age at delivery 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 to the expecting mother by the authorities after a report of pregnancy. The purpose of this handbook is the maintenance of maternal and child health, and it includes information on health check-ups during pregnancy, the condition of the newborn, the progress of infant growth, and periodic medical check-ups for the infant and vaccinations recorded by obstetricians or pediatricians. In addition, information on infertility treatment was obtained.

In Japan, the health check-up system after birth differs according to life stage. Until 6 years of age, children participate in health check-ups administered by the Ministry of Health, Labor and Welfare based on age, which is counted as actual weeks, months, or years after birth. The length/height data of children based on health check-ups are routinely recorded in the Handbook. Mothers participating in this study were advised to refer to these records when completing the questionnaire. Length/height growth data were assigned to the appropriate age groups on the basis of time (in days) since birth, which was calculated as the date at the check-up minus the child's birthday. The response rate was 65.9%. We had 1,143 triplet individuals having information on growth, but 82 triplets with unknown length/height or sex were excluded from the analyses. Ultimately, the subjects of this study were 354 mothers and their 1,061 triplet children. The mothers gave written informed consent to participate in the present study.

The means and standard deviations of length/height from birth to 6 years of age for triplets were calculated according to gestational age, very low birthweight, extremely low birthweight, sex, parity, birth order, infertility treatment, and maternal age at triplet delivery. The significance of differences between mean values was tested using mixed model ANOVA where the comparison was between two or more groups in order to adjust for familial clustering (i.e., sets of triplets) as a random effects factor. The SPSS statistical package, version 16.0 for Windows (2007) was used for statistical analysis.

The factors associated with birth length and height at one, three or six years of age were explored by linear mixed effects multiple regression analysis. This was done in order to adjust for familial clustering (i.e., sets of triplets) as a random effect factor. We fitted separate models for birth length and body height at 1, 3 and 6 years of age as dependent variables. The independent variables were gestational age, sex, parity, birth order of triplets, infertility treatment and maternal age at triplet delivery. Moreover in order to account for the starting point for postnatal growth, the regression analysis on factors associated with body height at 1, 3, and 6 years of age was done both with and without adjustment for birthweight and length.

The selected percentiles (3rd, 10th, 25th, 50th, 75th, 90th, and 97th) of length and height were calculated according to age and sex. Smoothing of growth curves was performed by cubic polynominal functions. The length/height deficit of the triplets was calculated as the percentage difference between the value of the general population and that of the triplets divided by the value of the general population. The length/height deficits were calculated using the 50th percentile values of the growth standards presented by the Ministry of Health, Labor and Welfare (Kato et al., 2001).

Table 1

Number of Triplet Individuals According to Sex and Age

	Length/Height	
	Male	Female
Birth	498	493
0 year		
1–2 months	95	114
2–3	51	45
3–4	196	180
4–5	133	148
5–6	107	108
6–7	167	138
7–8	91	92
8–9	83	86
9–10	145	124
10–11	104	101
11–12	55	64
1 year		
0–1	182	164
1–2	97	70
6–7	158	151
7–8	156	140
2 years		
0–6	247	239
6–12	29	30
3 years		
0–6	272	269
6–12	79	71
4 years		
0–6	195	190
6–12	27	32
5 years		
0–6	185	192
6–12	36	47
6 years		
0–6	148	133

Results

Table 1 presents the number of subjects according to sex and age for which length/height data were available. Table 2 summarizes the characteristics of the subjects. Gestational age at birth differ significantly by maternal age at triplet delivery ($P < .05$) and was 32.1

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Table 2

Major Characteristics of the Triplets

Gestational age (weeks)	≤ 28	66 (6.2%)
	29–32	286 (27.0%)
	33–36	604 (56.9%)
	37 ≤	93 (8.8 %)
	Unknown	12 (1.1%)
	Mean ± standard deviation	33.1 ± 2.65
	Range	25–38
Sex	Male	536 (50.5%)
	Female	525 (49.5%)
Parity	0	829 (78.1%)
	≥ 1	226 (21.3%)
	Unknown	6 (0.6%)
Infertility treatment	Not used	188 (17.7%)
	Used	852 (80.3%)
	Unknown	21 (2.0%)
Maternal age of delivery	< 25	22 (2.1%)
	25–29	348 (32.8%)
	30–34	517 (48.7%)
	35 ≤	168 (15.8%)
	Mean ± standard deviation	31.0 ± 3.59
	Range	20–42

± 3.39 weeks (mean ± standard deviation) in women aged less than 25 years, 33.3 ± 2.72 weeks in women aged 25 to 29 years, 33.2 ± 2.57 weeks in women aged 30–34 years and 32.8 ± 2.60 weeks in women aged 35 years or more.

Table 3 shows the mean length/height at birth and at 1, 3 and 6 years of age analyzed according to gestational age, very low birthweight, extremely low birthweight, sex, parity, birth order, infertility treatment and maternal age at triplet delivery. Females and triplets whose gestational age was earlier had a lower birth length and lower height at 1 and 3 years of age; these differences were statistically significant, except for the gender difference for height at 1 year of age. Extremely low birthweight infants had a lower birth length and lower height at 1, 3 and 6 years of age. Neonates born to multiparous women had higher birth length than neonates born to primiparous women. Triplets born to women aged less than 25 years had a lower height at 1 year of age than triplet children born to women aged 25 years or older.

Table 4 shows the results of linear mixed effects multiple regression analysis of birth length and height at 1, 3, or 6 years of age. We present regression coefficients, standard errors and p values for each covariate as well. Before adjusting birthweight and length, gestational age has the strongest contribution on length/height from birth to 3 years of age. Meanwhile, after adjusting for birthweight and length, birth length has the strongest contribution on height from 1 to 6 years of age, but birthweight also affected height at 1 and 3 years of age.

The percentiles of length/height are presented in Figure 1 (from birth to one year of age) and Figure 2 (from 1 to 6 years of age). The length/height deficit of the triplets in the 50th percentile was approximately 15% at birth relative to the growth standards of the general Japanese population (male, –7 cm; female, –7

Table 3

Birth Length and Body Height at 1, 3 and 6 Years of Age Among Japanese Triplets

		Birth length (cm)			1 year of age (cm)			3 years of age (cm)			6 years of age (cm)		
		N	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD
Gestational age	≤ 28	59	34.04	2.10***	31	67.88	3.02***	28	89.00	3.39**	13	108.73	5.35
	29–32	263	39.01	2.82	84	70.14	4.62	167	90.82	3.76	83	110.18	4.54
	33–36	577	42.71	2.43	186	72.40	2.48	291	91.61	3.57	149	111.32	4.37
	37 ≤	80	45.05	2.52	42	71.29	4.14	52	92.09	3.54	36	109.89	5.01
Very low birthweight infant	Yes	302	37.50	3.04***	130	69.23	3.73***	176	89.81	3.44***	92	109.33	4.65*
	No	689	43.09	2.37	216	72.55	2.97	365	91.97	3.56	189	111.34	4.43
Extremely low birthweight infant	Yes	68	33.35	2.02***	38	67.67	2.65*	40	88.19	2.87***	21	108.16	4.77**
	No	923	41.98	2.98	308	71.75	3.50	501	91.53	3.61	260	110.88	4.52
Sex	Male	498	41.66	3.79***	182	71.59	4.42	272	92.05	3.89***	148	111.10	4.60*
	Female	493	41.11	3.49	164	70.98	2.50	269	90.49	3.25	133	110.21	4.56
Parity	Multipara	214	42.03	3.64*	76	70.37	4.36	107	90.81	3.92	64	109.98	4.53
	Primipara	771	41.23	3.60	270	71.56	3.38	431	91.41	3.60	214	110.91	4.62
Birth order	First-born	330	41.54	3.48*	114	71.73	3.03	181	91.31	3.79	94	110.67	4.13*
	Second-born	331	41.48	3.65	116	71.17	3.97	181	91.46	3.49	93	111.26	4.25
	Third-born	330	41.15	3.81	116	71.01	3.84	179	91.06	3.73	94	110.12	5.28
Infertility treatment	Not used	172	41.44	3.45	68	70.84	3.94	100	91.34	3.17	43	109.43	4.40
	Used	798	41.36	3.71	269	71.35	3.60	435	91.23	3.79	232	110.82	4.60
Maternal age at triplet delivery	< 25	16	39.04	3.91	9	66.83	5.37*	15	89.25	5.08	3	106.17	1.00
	25–29	320	41.57	3.71	113	71.69	3.06	169	91.72	3.86	81	111.50	3.99
	30–34	490	41.35	3.63	163	71.47	3.97	282	91.34	3.42	154	110.83	4.72
	35 ≤	165	41.38	3.53	61	70.80	3.01	75	90.47	3.60	43	108.93	4.82

Note: SD: standard deviation; All variables included in the model; * $P < .05$, ** $P < .01$, *** $P < .001$.

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Table 4

Result of Mixed Effects Multiple Regression Analysis of Factors Associated with Body Length

	Without adjusting for birthweight and length					With adjusting for birthweight and length					
Dependent variable	Explanatory variable	Regression coefficient	Standard error	p-value	Adjusted R^2	Dependent variable	Explanatory variable	Regression coefficient	Standard error	*p*-value	Adjusted R^2
Birth length	Gestational age	0.775	0.028	$P < .001$	0.607						
	Sex	–0.112	0.149	$P < .001$							
	Parity	0.053	0.193	$P = .015$							
	Birth order	–0.039	0.091	$P = .053$							
	Infertility treatment	0.035	0.208	$P = .104$							
	Maternal age at triplet delivery	0.022	0.022	$P = .298$							
Length at 1 year	Gestational age	0.372	0.062	$P < .001$	0.148	Length at 1 year	Birthweight	0.393	0.001	$P < .001$	0 .314
	Sex	–0.083	0.374	$P = .104$			Birth length	0.359	0.102	$P < .001$	
	Parity	–0.110	0.475	$P = .043$			Gestational age	–0.249	0.107	$P = .005$	
	Birth order	–0.086	0.226	$P = .087$			Sex	–0.076	0.346	$P = .111$	
	Infertility treatment	0.096	0.499	$P = .081$			Parity	–0.107	0.432	$P = .034$	
	Maternal age at triplet delivery	0.005	0.053	$P = .924$			Birth order	0.013	0.215	$P = .788$	
							Infertility treatment	0.073	0.456	$P = .153$	
							Maternal age at triplet delivery	–0.054	0.050	$P = .273$	
Length at 3 years	Gestational age	0.186	0.059	$P < .001$	0.083	Length at 3 years	Birthweight	0.285	0.001	$P = .005$	0.212
	Sex	–0.209	0.308	$P < .001$			Birth length	0.312	0.087	$P < .001$	
	Parity	–0.052	0.402	$P = .233$			Gestational age	–0.262	0.092	$P < .001$	
	Birth order	–0.014	0.188	$P = .728$			Sex	–0.151	0.293	$P < .001$	
	Infertility treatment	0.002	0.421	$P = .972$			Parity	–0.093	0.376	$P = .030$	
	Maternal age at triplet delivery	–0.032	0.045	$P = .456$			Birth order	0.046	0.182	$P = .273$	
							Infertility treatment	–0.009	0.401	$P = .838$	
							Maternal age at triplet delivery	–0.059	0.043	$P = .156$	
Length at 6 years	Gestational age	0.100	0.101	$P = .101$	0.028	Length at 6 years	Birthweight	0.288	0.002	$P = .082$	0.168
	Sex	–0.089	0.560	$P = .142$			Birth length	0.419	0.184	$P = .006$	
	Parity	–0.048	0.682	$P = .442$			Gestational age	–0.440	0.179	$P < .001$	
	Birth order	–0.054	0.338	$P = .368$			Sex	–0.072	0.537	$P = .220$	
	Infertility treatment	0.115	0.805	$P = .073$			Parity	–0.091	0.662	$P = .142$	
	Maternal age at triplet delivery	–0.108	0.079	$P = .073$			Birth order	0.043	0.331	$P = .468$	
							Infertility treatment	0.054	0.772	$P = .393$	
							Maternal age at triplet delivery	–0.078	0.080	$P = .206$	

Note: All explanatory variables included in the model.

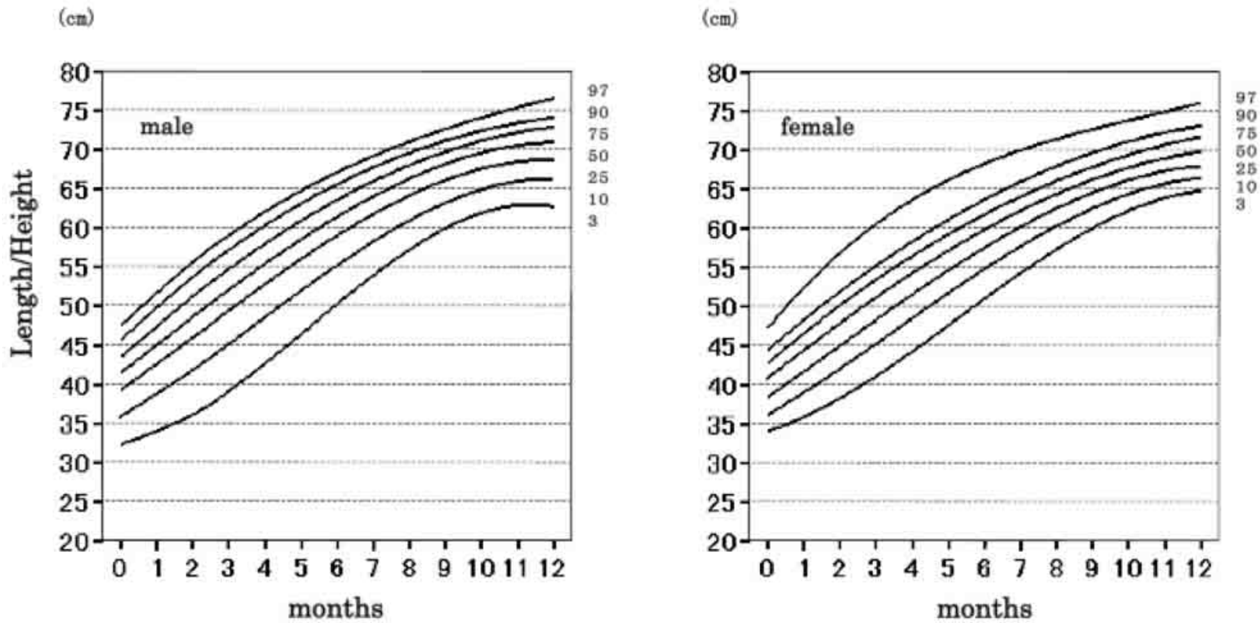

Figure 1

Body length/height of triplets according to age percentiles from birth to 1 year of age.

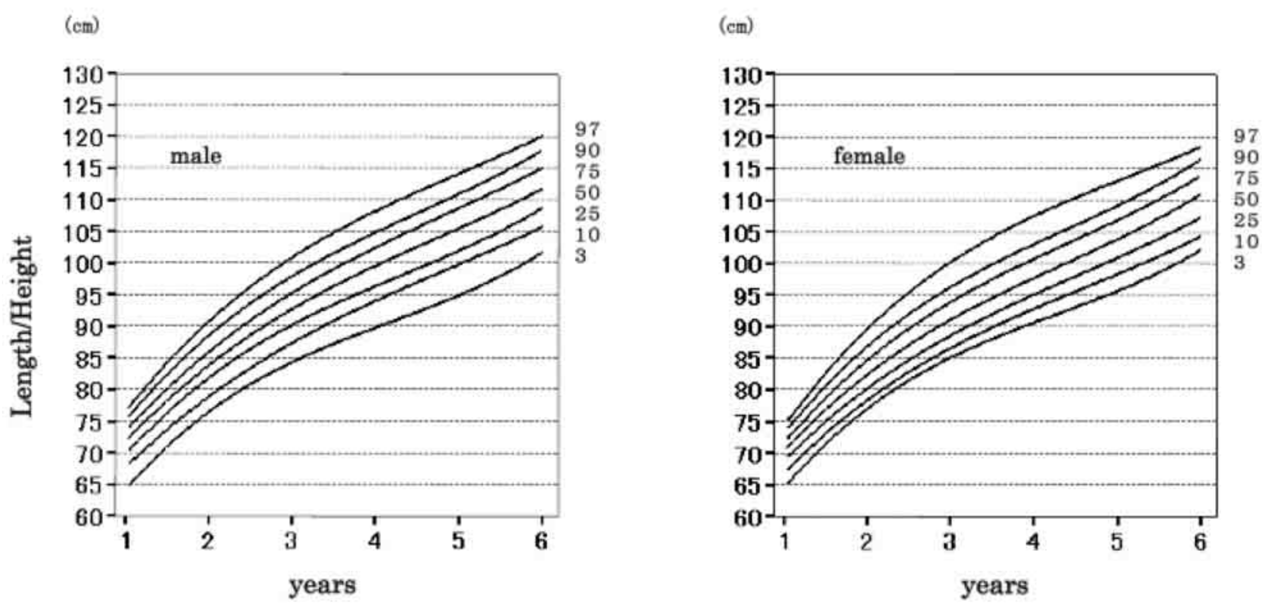

Figure 2

Body length/height of triplets according to age percentiles from 1 to 6 years of age.

cm). The deficit decreased rapidly within the first year of age, but fluctuated between 2% and 5% until 6 years of age (male, –3.7 cm; female, –3.3 cm) (Figure 3).

Discussion

Despite the rapid increase in multiple births and subsequently the augmenting need to provide appropriate information to their parents, there are no length/height growth charts after birth for triplet children in the world. The present data are the largest triplet sample in the world to provide accurate data for age after birth.

Birth length showed the strongest contribution to body height of triplets until six years of age. In addition, birthweight was also a significant contributing factor to height from one to three years of age. Moreover, gestational age had a significant effect on length/height of triplets from birth to 6 years of age. With adjusting for birthweight and length, contraction of gestational age affected taller height until 6 years of

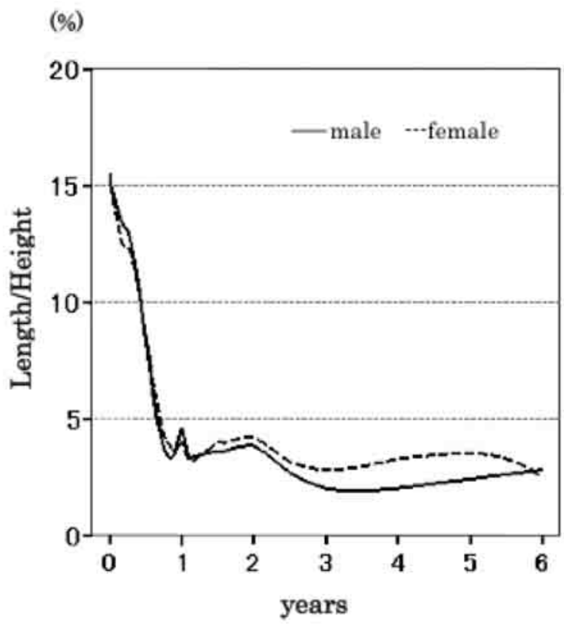

Figure 3
Length/height deficit of triplets as to the 50th percentiles compared with general population from birth to 6 years of age.

age, suggesting that height of triplets increased with every increase in birth length or birthweight for gestational age. These results are consistent with that reported by Pietilainen et al. (2001), who found in Finnish twin data that height until adolescence was predicted by length and weight at birth.

Meanwhile, our data show that extremely low birthweight infant had a lower length/height from birth to 6 years of age. Albertsson-Wikland et al. (1998) indicated that children born small for gestational age that remained short at 2 years of age had a higher risk of short stature later in life. It is probable that extremely low birthweight and extremely low birth length affects growth of height after birth in triplets. Infants with extremely low birthweight and extremely low birth length may need longitudinal follow-up.

Sex was a significant factor affecting length/height at birth and 3 years of age. Male triplets had a higher length/height than females. This result is in accordance with previous reports on twins (Buckler & Green, 2004; Ooki & Yokoyama, 2004) and singletons (Britton et al., 1993). The effects of parity, birth order, and maternal age at triplet delivery were very small and mostly disappeared at an early age. In the present study, lasting effects of gestational periods and birth length on body height until 6 years of age were observed. However, the growth standards of the general population did not correct the effects of gestational age and birth length to reflect the actual condition of physical growth. The present data should be treated in the same way in order to estimate the difference between the general population and triplets. Therefore in the present study, the growth charts for the triplets were differentiated only according to sex.

Compared to the 50th percentile of growth standard for the general population of Japan, the length/height deficit of Japanese twins is approximately 6% at birth and gradually decreased, reaching 3% in the first 7 to 8 months and is as low as 0–1%, around 1 cm, by 6 years of age (Ooki & Yokoyama, 2004). However, in the present study, the length/height deficit of the triplets, which was approximately 15% at birth, decreased within the first year, but remained between 2% and 5% until 6 years of age. The difference of height between the general population and triplets was approximately 3 cm at 6 years of age. The present data suggest that a triplet pregnancy has a greater effect on future growth of height than a twin pregnancy. However, the sample size of this study was not as large as the aforementioned twin sample (Ooki & Yokoyama, 2004). Further follow-up is needed to investigate whether triplets achieve normal length/height later in life. We intend to investigate next the physical growth of triplets after 6 years of age, including increasing the number of subjects.

Regarding other factors associated with length/height of triplets, parity had significant effects on birth length: multiparous neonates were bigger at birth. Our result is consistent with that reported by Kato and Uchiyama (2005) who also found that multiparous twins had greater birth lengths than primiparous neonates. However, in the present study, regression analysis showed that triplets born to multipara had lower heights at 1 and 3 years of age than those born to primipara. This reason is unclear. It is probable that multiparous mothers are very busy and chose bottle-feeding with formula milk only. Martin et al. (2002) indicated that infants breast-fed were taller in childhood compared with bottle-fed infants. Unfortunately, data on breast-feeding is lacking in this study. Data on zygosity, maternal smoking, maternal pregravid weight, length/height, previous obstetric outcome, and maternal weight gain during pregnancy are also lacking in this study, and it has been suggested that these factors are associated with length/height growth (Luke et al., 2002; Ooki & Yokoyama, 2003; Vogazianos et al., 2005).

The limitation of the present study was that these data were semi-longitudinal. Specifically, data on the same individual were used according to the recorded times. Some of our subjects provided most of the required longitudinal data. On the other hand, others provided data only from birth to 1 year of age. Additionally, the number of subjects in each age group varied considerably. Consequently, the range of measurements in each group becomes small. The clinical use of 3rd percentiles and 97th percentiles of this growth charts as indicators of growth retardation might not be necessarily appropriate.

In conclusion, triplets have lower birth length/height than singletons and in spite of the catch-up growth during first year of life they are behind singletons even in mid-childhood. This study provides length/height growth curves for use in triplets. Further follow-up of the triplets should reveal whether and when their growth eventually catches up with singletons.

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