Comparison of Motor Development Between Twins and Singletons in Japan: A Population-Based Study

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This study was performed using population-based data to analyze whether motor development in early life is different between singletons and twins in Japan. For better comparison and investigation, we divided the 2 groups into a group with a birthweight of 2.5 kg or greater (subgroup A) and a group with a birthweight of less than 2.5 kg (subgroup B), respectively. We analyzed the database of medical check-ups for children aged 3 years between April 2001 and July 2004. They received medical check-ups at 4 months, 1.5, and 3 years of age. Children who were suspected of having neurological abnormality or disability were referred to specialists and excluded from the database. The data of 14,132 children were analyzed. Among these, 13,040 (92.3%) children were singletons in subgroup A, 75 (0.5%) were twins in subgroup A, 866 (6.1%) were singletons in subgroup B and 151 (1.1%) were twins in subgroup B. The mean age at achieving milestones was slower in twins of subgroup A for each developmental outcome than singletons of subgroup A, and the difference between twins and singletons was significant after adjustment for rolling over. On the contrary, after adjusting for a confounding factor (gestational age), singletons of subgroup B attained motor development facilitating walking independently slower than twins of subgroup B. There were different tendencies in the results regarding the motor development of subjects of subgroup A and that of subjects of subgroup B.

In Japan, like other developed countries, multiple births have been increasing because of infertility treatment, whereas the birth rate is decreasing. The twinning rate per 1000 births was 6.4 in 1951 and increased to 9.9 in 2001 (Imaizumi, 2003). The mortality rate of twin infants is higher than that of singleton infants (Imaizumi, 2001; Kato & Matsuda, 2006), and morbidity associated with multiple births including twinning is an important public health problem.

Meanwhile, the attainment of gross motor milestones is a significant indicator of motor development in early life. Motor development is likely to play an important role in the long-term neurodevelopmental status (Peter et al., 1999). This development can be impaired by a number of conditions (Bhargava, 2000; Gross, 1991; Koeppen-Schemerus et al., 2000; Sherriff et al., 2001). In particular, a low birthweight (LBW < 2.5 kg) and preterm delivery (< 37 weeks) were indicated for the associations with developmental delay in early life (Francis-Williams & Davies, 1974; Hediger et al., 2002).

Twins are prone to developmental delay due to prematurity and a low birthweight (Myianthopoulos et al., 1976). Indeed, many twins are born as preterm infants with a low birthweight (Arbuckle et al., 1993; Glinianaia et al., 2000; Kato, 2004). However, a study in The Gambia reported that twinning is an independent risk factor for developmental delay in early life after adjusting for confounding factors. There have been few studies evaluating whether motor development in early life is different between singletons and twins in Japan. This present study was therefore performed using population-based data to analyze whether motor development in early life is different between singletons and twins. For better comparison and investigation, we divided the two groups into a group with a birthweight of 2.5 kg or greater (subgroup A) and a group with a birthweight of less than 2.5 kg (subgroup B), respectively.

Subjects and Methods

In Japan, medical check-ups of all infants have been well established by the Maternal and Child Health Law at less than 1 year, 1.5, and 3 years of age. Pediatricians carry out these medical check-ups and public health nurses advise on child-rearing at these occasions. Thus, these medical check-ups are given to almost 100 % of children in Japan. The data from these medical check-ups are filed in the city public health department. These data, except personal

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Table 1

Motor Milestones and Their Definitions

Maintain head	Assessed by pulling the baby's arms.
Roll over	Assessed if the child was able to roll over completely from prone to supine or supine to prone.
Sit without support	Defined as sitting up and maintaining the head position without rear support.
Crawl	Assessed if the child was able to move forwards or backwards either on the stomach or on hands and knees.
Sit up	Assessed if the baby was able to move from a lying to a sitting position independently.
Stand holding on	Defined as maintaining a standing position by holding on to ones hand.
Walk holding on	Defined as walking a few steps by holding on to ones hand.
Stand independently	Assessed if the child was able to stand independently.
Walk independently	Assessed if the child was able to walk independently.

information, are transcribed into computerized files in Nishinomiya City. Nishinomiya is a residential area and has a population of approximately 460,000. Birth numbers per year are about 4700.

We analyzed the database of the medical check-ups for children aged 3 years between April 2001 and July 2004. They received medical check-ups at 4 months, 1.5, and 3 years of age. Children who were suspected of having neurological abnormality or disability were referred to specialists and excluded from the database. This database contains data on gestation number, gestational age, birthweight, birth length, head circumference at delivery, parity, mode of delivery, and age of parents at delivery. The ages of attainment of a set of gross motor milestones were obtained from records in the *Maternal and Child Health Handbook*. This handbook was stipulated by the Maternal and Child Health Law in Japan and is provided after pregnancy is reported. The purpose of this handbook is the preservation of maternal and child health and its records: medical check-ups during pregnancy and the condition of the newborn recorded by obstetricians, the ages of attainment of gross motor milestones recorded by the parents, and the progress of infant development checked by pediatricians at medical check-ups. The milestones considered for this study are defined in Table 1, and were adopted from the Denver Development Screening Test (Frankenburg & Dodds, 1967).

With regard to statistical analyses, the independence of qualitative variables was examined using chi-square analysis, and the significance of differences

Table 2

Major Characteristics of Subjects in Each Subgroup

	Subgroup A (birthweight ≥ 2.5 kg)		Subgroup B (birthweight < 2.5 kg)	
	Singletons *N* = 13,040 *N* (%)	Twins *N* = 75 *N* (%)	Singletons *N* = 866 *N* (%)	Twins *N* = 151 *N* (%)
Sex				
Male	6718 (51.5)	39 (52.0)	407 (47.0)	69 (45.7)
Female	6322 (48.5)	36 (48.0)	459 (53.0)	82 (54.3)
Parity				
Primipara	7246 (55.6)	47 (63.5)	540 (62.4)	109 (72.7)*
Multipara	5792 (44.4)	27 (36.5)	326 (37.6)	41 (27.3)
Mode of delivery				
Vaginal delivery	11,551 (88.6)	34 (45.3)***	630 (72.7)	56 (37.1)***
Cesarean section	1489 (11.4)	41 (54.7)	236 (27.3)	95 (62.9)
Maternal age at delivery (years)				
Mean ± *SD*	29.6 ± 3.91	30.6 ± 4.21*	29.7 ± 4.23	30.7± 4.00**
Range	16–46	22–40	17–42	19–43
Father's age at delivery (years)				
Mean ± *SD*	31.9 ± 4.89	33.1±5.43	32.3 ± 5.23	33.2 ± 4.71*
Range	16–62	8–44	18–60	21–47

Note: $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

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Table 3

Gestational Age and Body Size Parameters at Birth of Subjects in Subgroups A (Birthweight ≥2.5 kg) and Subgroup B (Birthweight < 2.5 kg)

	Subgroup A (birthweight ≥ 2.5 kg)		Subgroup B (birthweight < 2.5 kg)	
	Singletons N = 13,040 N (%)	Twins N = 75 N (%)	Singletons N = 866 N (%)	Twins N = 151 N (%)
Gestational age (weeks)				
≥ 37	12,801(98.2)	62 (82.7) ***	560(64.7)	56 (37.1)***
32–36	229 (1.8)	13 (17.3)	259 (29.9)	87 (57.6)
< 32	1 (0.0)	0 (0.0)	47 (5.4)	8 (5.3)
Mean ± SD	39.2±1.23	37.5±1.24	36.8 ± 2.63	35.6 ± 2.31
Birthweight (g)				
Mean ± SD	3119.6 ± 338.7	2745.8 ± 211.5 ***	2226.1 ± 324.8	2115.3 ± 341.5
Range	2500–5090	2500–3356	718–2498	645–2498
Birth length (cm)				
Mean ± SD	49.1 ± 1.79	47.5 ± 1.52 ***	45.1 ± 2.71	44.5 ± 2.86
Range	33 – 60	43–50	30–51	29–50
Head circumference				
Mean ± SD	33.3 ± 1.31	33.2 ± 1.13	31.2 ± 1.76	31.4 ± 1.95
Range	24 – 45	31–36	23–42	21–35

Note: Excluding persons with unknown gestational age.

***p < .001.

between mean values was examined using the t test. Furthermore, age at developmental outcome as the dependent variable was compared for twins and singletons using multiple linear regressions, adjusting for gestational age, birthweight, and birth length. The SPSS statistical package v11.5 for Windows (2002) was used for statistical analyses.

Results

Between April 2001 and July 2004, a total of 14,132 children aged 3 years underwent medical check-ups in Nishinomiya City, excepting 84 children who were suspected of having neurological abnormality or disability and 690 children who did not undergo medical check-ups because of a range of reasons. Overall, 13,040 (92.3%) children were singletons in subgroup A, 75 (0.5%) were twins in subgroup A, 866 (6.1%) were singletons in subgroup B, and 151 (1.1%) were twins in subgroup B.

Table 2 summarizes the characteristics of the subjects in each subgroup. There was a significantly higher rate of infants who underwent cesarean section among twins than among singletons in both subgroup A and subgroup B (p < .001, p < .001).

As shown in Table 3, gestational age was significantly higher among singletons than among twins in both subgroup A and subgroup B (p < .001, p < .001). In subgroup A, twins had a lower birthweight than singletons and a shorter birth length.

Table 4 shows ages of milestone achievements in twins and singletons of subgroup A. The ages of milestone achievements were significantly higher in twins for each outcome compared to singletons. Moreover, after adjustment for gestational age, birthweight, and birth length, in which there were differences between twins and singletons of subgroup A, the difference was significant for rolling over (p = .04). No significant difference was observed for maintaining head (steadily), sitting without support, sitting alone, crawling, standing (holding on), walking (holding on), standing independently, and walking independently.

Table 5 shows ages of milestone achievements in twins and singletons of subgroup B. The age of milestone achievement was higher in twins for maintaining head (steadily), but after adjustment for gestational age, for which there was a difference between twins and singletons of subgroup B, no significant difference was observed for maintaining head (steadily). However, with regard to subgroup B, after adjustment, the age of milestone achievement was significantly higher in singletons than twins for walking independently.

Discussion

Our population-based study identified different tendencies in the results of subgroup A with a birthweight 2.5 kg or greater and that of subgroup B with a birthweight of less than 2.5 kg. The result in subgroup A suggested that twins attained gross motor milestones in early life slower than singletons. The association was confounded by gestational age, birthweight, and birth length, but a significant difference between twins and singletons was also observed

Table 4

Age of Milestone Achievement in Twins and Singletons of Subgroup A (Birthweight ≥ 2.5 kg)

	Singletons *N* = 13,040 Mean (95%CI)	Twins *N* = 75 Mean (95%CI)	*p* value	Adjusted *p* value
Maintain head (*n* = 12,351)	3.23 (3.21–3.24)	3.41 (3.24–3.59)	.031	.535
Roll over (*n* = 10,006)	4.98 (4.96–5.01)	5.61 (5.28–5.95)	<.001	.040
Sit (alone) (*n* = 12,207)	6.64 (6.62–6.65)	7.03 (6.81–7.24)	.001	.058
Crawl (*n* = 10,007)	7.74 (7.71–7.77)	8.27 (7.92–8.62)	.004	.183
Stand holding on (*n* = 10,186)	8.55 (8.52–8.58)	9.12 (8.84–9.41)	.004	.131
Walk holding on (*n* = 9892)	9.70 (9.67–9.73)	10.28 (9.92–10.65)	.007	.169
Stand alone (*n* = 9202)	10.94 (10.91–10.98)	11.41 (11.11–11.71)	.047	.459
Walk independently (*n* = 12,386)	12.32 (12.29–12.36)	12.86 (12.44–13.29)	.022	.421

Note: Adjustment was made for gestational age, birthweight, and birth length.

after adjustment. In The Gambia, Goetghebuer et al. (2003) studied twins and singletons with a birthweight of greater than 2.5 kg, and indicated that twinning was an independent risk factor for the delay of gross motor milestones in early life. This report by Goetghebuer et al. is consistent with the results of subjects with a birthweight of 2.5 kg or greater in the present study.

However, there were some discrepancies between this study and the study of Goetghebuer et al. (2003). They reported that the difference between twins and singletons with a birthweight of greater than 2.5 kg was significant after adjustment for maintaining head, sitting without support, and walking, whereas in our study, the difference between twins and singletons with a birthweight of 2.5 kg or greater was significant after adjustment for rolling over. In addition, we observed that all gross motor milestones were attained at earlier ages by Gambian singletons with a birthweight of greater than 2.5 kg compared to Japanese singletons with a birthweight of 2.5 kg or greater. Especially, the mean age of attaining an ability to maintain the head position was 2.53 months and 3.56 months in Gambian singletons and Japanese singletons, respectively, with the difference being almost 1 month. Ethnic differences were reported by Iloeje et al. (1991), who showed that black children attained gross motor milestones earlier than white children. The discrepancies between the study of Goetghebuer et al. and this study may result from ethnic differences.

Meanwhile, as a result of subgroup B showing a different tendency from that of subgroup A, and after adjusting for a confounding factor (gestational age), singletons with a birthweight of less than 2.5 kg attained motor development facilitating walking independently slower than twins with a birthweight of less than 2.5 kg. These data suggest that singletons with a birthweight of less than 2.5 kg may be disadvantaged in their developmental status, especially concerning walking in early life, compared to twins. Morley et al. (1989) showed that there were no significant differences in development between twins under 32 weeks of gestation and singletons. Although the subjects in both studies were infants with a birthweight of less than 2.5 kg, this report by Morley et al. was inconsistent with our results. The study of Morley et al. was a cross-sectional observation at 18 months of age, while the present study was a population-based study using medical check-ups and *Maternal and Child Health Handbook* records, which are less subject to bias.

Luke (1996) showed that the lowest fetal death rate was at birthweights of 3.7 to 4.0 kg for singletons and 2.5 to 2.8 kg for twins, and twins achieved maturity at a lower birthweight compared to singletons. Moreover, it has been indicated that smaller individual sizes in multiple gestations were better described as a growth adaptation when comparing the entire fetal mass of a multiple pregnancy to that of singletons (Blickstein, 2002, 2004). The results observed in the present subjects with a birthweight of less than 2.5 kg could be due to differences between the optimal birthweight of singletons and that of twins, or differences in the uterine environment to achieve maturity.

On the contrary, the delay observed in twins with a birthweight of 2.5 kg or greater could be due to prenatal factors that do not affect gestational age, birthweight, and length, such as a reduced space in the uterus or limitation of uterine capacity including nutrition. Although the uterus has a remarkable

Table 5

Age of Milestone Achievement in Twins and Singletons of Subgroup B (Birthweight < 2.5 kg)

	Singletons *N* = 866 Mean (95%CI)	Twins *N* = 151 Mean (95%CI)	*p* value	Adjusted *p* value
Maintain head (*n* = 924)	3.56 (3.49–3.62)	3.82 (3.62–4.01)	.003	.424
Roll over (*n* = 734)	5.57 (5.46–5.69)	5.55 (5.32–5.79)	.891	.227
Sit (alone) (*n* = 912)	7.05 (6.96–7.13)	7.27 (7.05–7.49)	.070	.575
Crawl (*n* = 737)	8.23 (8.10–8.35)	8.17 (7.90–8.45)	.746	.202
Stand holding on (*n* = 748)	9.14 (9.00–9.28)	9.19 (8.93–9.45)	.797	.515
Walk holding on (*n* =738)	10.36 (10.20–10.51)	10.35 (10.03–10.66)	.977	.398
Stand alone (*n* = 676)	11.61 (11.44–11.78)	11.55 (11.23–11.87)	.074	.225
Walk independently (*n* = 926)	13.08 (12.92–13.23)	12.98 (12.65–13.31)	.621	.030

Note: Adjustment was made for gestational age.

ability to expand and adapt (Dwight et al., 1993; Steingrimsdottir et al., 1995; Yokoyama, 2002), the potential to increase its volume and nutritional capacity is limited. In most cases of twins with a birthweight of 2.5 kg and greater, the total twin birthweights exceed 5 kg. Malinowska et al. (1998) showed that the shortening of twin pregnancy duration was caused by a factor that the total fetal body mass attained 5.5 kg, and this point may indicate the main limitation of uterine capacity. In the meanwhile, twin births represent a greater child care burden to the parents (Yokoyama et al., 2004; Yokoyama & Ooki, 2004), which may result in less stimulation of the infants, and therefore less opportunity for gross and fine motor experiences in early life. The reason for the delay observed in twins with a birthweight of 2.5 kg or greater should be investigated in the future.

Data on weight at 1 year of age, feeding methods, and maternal behavior were lacking in this study, and it has been suggested that these factors are associated with developmental status (Angelsen et al., 2001; Goetghebuer et al., 2003; Ostfeld, 2000). These factors will be investigated in the future.

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