Original Article

Retrospective tracking of young obese children back to birth in Japan: special attention to the relationship with parental obesity

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Objective: Childhood obesity is tracked to adulthood at a high rate. However, longitudinal studies of obesity in early childhood remain limited. This study aimed at tracking young obese children back to birth in comparison with normal-weight children, and investigating the relationship with parental obesity. **Methods**: A total of 2,678 (1,353 boys) young children attending kindergarten or nursery school in Nara Prefecture, Japan, were enrolled. The present heights and weights of children and parents were obtained by a questionnaire, and children's heights and weights at birth, 1.5, and 3.5 years were obtained from mother-child health notebooks. Using body mass index (BMI), child and parental obesity were defined as ≥90th percentile based on the reference values for Japanese children and ≥25 (kg/m²), respectively. **Results**: The overall prevalence of obesity at birth was 10.2%, and decreased to 5.6% at 5 years. In the retrospective tracking, obese children at 5 years exhibited significantly higher weight z-scores and BMI percentiles consistently from birth than in normal-weight children. The increased velocity of weight gain as judged by their z-score during three periods; birth-1.5, 1.5-3.5, and 3.5-5 years were significantly associated with an increased risk for the obesity at 5 years of age. Only maternal obesity was found to be associated with daughters' obesity in the analysis of association of parents-children obesity. **Conclusions**: It is important to manage body weight from early infancy for reducing the occurrence of obesity at 5 years. Where there is maternal obesity, greater attention may be required, especially for daughters.

Key Words: body mass index, obesity, parental obesity, tracking, young children

INTRODUCTION

The increase in childhood overweight and obesity is a major public health concern in both developed and developing countries.[1,2] In the Japanese national census, the prevalence of childhood obesity increased to 8%-12% in the 1990s, which is 3 times higher than that in the 1970s.[3] Overweight or obesity in childhood has various adverse effects on health in childhood and adulthood.[4] For example, in the Bogalusa Heart Study, 70% of overweight children had at least one cardiovascular risk factor such as excess adiposity, adverse levels of lipids, insulin and blood pressures.[5] The Japanese study using children aged 6-12 years demonstrated that even mild obesity can be a risk factor for emergence of insulin resistance.[6] Furthermore, an increase of BMI SD scores by serial measurements of BMI during childhood was shown to be a good predictor for the occurrence of metabolic syndrome in adulthood.[7]

In the analysis of the relationship between obesity in childhood and in adulthood, several studies have reported that children who are overweight or obese in childhood have an increased risk of remaining overweight or obese in adulthood.[8-10] The earlier study indicated that critical periods for the development of child obesity are gestation, early infancy, and adolescence.[11] Among them, rapid weight gain during infancy in particular is thought to be a significant risk factor for later childhood and adulthood obesity.[12-14] Although it would seem imperative to prevent accelerated weight gain during infancy, longitudinal studies of obesity from birth to infancy still remain limited, particularly in Asian countries including Japan.

It is known that parental obesity, through the influence of genetics, maternal programming and environmental factors, is an important risk factor for child obesity.[15,16] Although various studies targeted at different ages of children on this issue, large-scale studies from America, Europe, and Asia have found associations between parental and preschool children's obesity.[17-20] However, the degree of strength of such association was quite diverse among studies. Another issue of how paternal or maternal obesity is linked with boys' or girls' obesity still remains controversial. For example, Perez-Pastor found that child obesity was linked to parent's obesity in the same-sex parent,[21] while other investigators found that both par-

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ents' BMIs had an effect on the BMI of their children.[22] Particularly, Whittaker et al have reported that mother-child associations for BMI were significantly stronger than father-child associations.[20]

Based on the knowledge above, the objectives of the present study were; 1) to track young obese children back to birth, compared with normal-weight children; 2) to examine the relationship between parental obesity and the obesity of their children at 5 years of age, especially the possibility of a mother-child or father-child association.

METHODS

Subjects

Nara is a rural prefecture in Japan with a population of approximately 1,400,000 and 570,000 households. According to the census taken in 2013, the mean annual income of these households was almost identical to the average household income in the whole Japan. At the time of investigation, there were 181 public kindergartens and 212 nursery schools in Nara Prefecture. We invited all of the public kindergartens and nursery schools to participate in the present study, and obtained consent from 68 kindergartens (37.6%) and 67 nursery schools (31.6%). The investigation was conducted between November 2012 and September 2013, with an initial number of 7,777 children (kindergarten, 4,479; nursery school, 3,298). Of these, 4,792 questionnaires (total, 61.6%; kindergarten, 3,044, 68.0%; nursery school, 1,748, 53.0%) were returned. Finally, a total of 2,678 5-years-old children (1,353 boys, 1,325 girls) were enrolled in this study after exclusions for the following reasons: 1) unknown gender, 2) incomplete questionnaire, or 3) birth weight less than 2.0 kg or equal to or more than 4.0 kg. This project was approved by the ethical and epidemiological committee at Nara Women's University (24/6/6-1). We thought that the consent from parents was obtained when they sent us the questionnaire after fulfilling the necessary data.

Questionnaire

The questionnaire included the height and weight of the children from birth to 5 years of age, and the present height and weight of their parents. All responses were reported by the parents. The height and weight of the children were obtained from the records of mother-child health notebooks.

Definition of obesity and thinness

BMI was calculated as body weight in kilograms divided by height in square meters (kg/m^2). It is known that there are ethnic differences in body composition including BMI, body fat mass and fat distribution between Japanese and Caucasian children.[23] Based on the BMI standard established by the Japanese Association for Human Auxology,[24] child obesity and thinness are defined as a BMI equal to or more than the 90th percentile, and a BMI less than the 5th percentile, respectively. Cole et al reported that a BMI of 25.0 at age 18 corresponded to the 90th percentile for males and the 88th percentile for females.[25] Therefore, considering the definition of obesity as BMI≥25.0 in Japanese adults,[26] we thought that the 90th percentile was a suitable cut-off value for obesity at a given age in the present study. The BMI 5th percentile has been widely used to define childhood and adolescent underweight.[2] Parental obesity was defined as BMI≥ 25.0.[26]

Data analysis

Since there were no statistical differences in the physical characteristics of the children and their parents between the data from kindergartens and those from nursery schools, these data were combined for the further analysis. Differences in the prevalence of obesity according to gender and age were examined by the chi-square test and Cochran-Armitage test, respectively. In the retrospective tracking of physical characteristics among normal-weight and obese children defined by BMI 90th percentile at 5 years, Student t-test was used for the comparison of various variables. The relationship of parental obesity to the obesity of the children at 5 years was examined by the chi-square test and expressed as odds ratio (OR) and 95% confidence interval (CI). Data analysis was performed by using Excel Statistics, version 2010 (SSRI Co. Ltd, Tokyo, Japan). p values less than 0.05 were considered significant.

RESULTS

Comparison of the prevalence of obesity by gender and age

The prevalence of obesity at birth, 1.5, 3.5, and 5 years was 10.2%, 11.1%, 8.4%, and 5.6% in all children, 9.5%, 9.2%, 8.2%, and 5.4% in boys, and 10.9%, 13.1%, 8.6%, and 5.8% in girls, respectively, demonstrating no statistical differences between genders except for that at 1.5 years (p<0.01) (Figure 1). In addition, the prevalence was found to decrease significantly with age in both genders (p<0.001).

Retrospective tracking of physical characteristics in normal-weight and obese children as classified by BMI percentile at 5 years of age

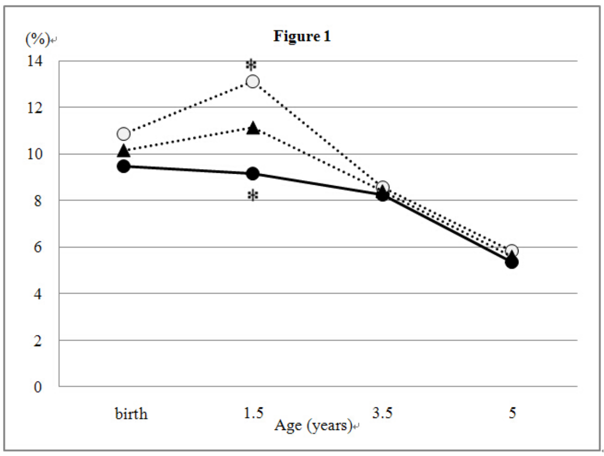

Figure 1: Changes in the prevalence of obesity with age. (▲) Total (n=2678), (●) Boys (n=1353), (○) Girls (n=1325). *The prevalence of obesity at 1.5 years in girls is significantly higher than that in boys (Chi-square test: p<0.01). There were no significant differences between genders at birth (p=0.23), 3.5 years (p=0.75), and 5 years (p=0.59) (Chi-square test). The prevalence of obesity decreased significantly with age in both genders (Cochran-Armitage test: p<0.001).

All children at 5 years of age were classified into 1 of 3 groups (thin, normal-weight, obese) based on the BMI percentile. One hundred-five children who belonged to the thin group were excluded from the analysis, since we thought that thin children are a distinct population from normal-weight children. Actual values and z-scores of height and weight, increments of height and weight, and BMI percentiles were retrospectively tracked from birth to 5 years in boys (Table 1) and girls (Table 2). In both genders at birth, 1.5 years, and 3.5 years, actual weight and their z-scores, and actual BMI and their percentiles were significantly greater in obese children than those in normal-weight children. In addition, the increments of actual weight and their weight z-scores during birth-1.5 years, 1.5-3.5 years, and 3.5-5 years were consistently greater in obese children than those of normal-weight

Table 1. Comparison of the physical characteristics at each time point based on the body status at 5 years in boys

	Body status at 5 years		p-value*
	Normal-weight (n=1220)	Obese (n=79)	
Height (cm)			
Birth	49.1±2.3†	49.6±2.3	<0.05
1.5 y	80.9±4.4	81.2±6.3	0.29
3.5 y	96.5±4.8	98.0±5.6	<0.01
5 y	104±4.5	106±5.6	<0.001
Increment of height (cm)			
Birth - 1.5 y	31.8±4.5	31.6±6.1	0.35
1.5 y - 3.5 y	15.6±3.6	16.8±4.7	<0.01
3.5 y - 5 y	7.6±4.3	8.3±5.0	0.10
Height z-score			
Birth	0.04±1.08	0.28±1.08	<0.05
1.5 y	0.14±1.59	0.25±2.24	0.29
3.5 y	-0.10±1.30	0.29±1.50	<0.01
5 y	0.17±1.10	0.68±1.37	<0.001
Increment of height z-score			
Birth - 1.5 y	0.10±1.71	-0.03±2.22	0.26
1.5 y - 3.5 y	-0.24±1.14	0.05±1.62	<0.05
3.5 y – 5 y	0.27±1.12	0.39±1.28	0.18
Weight (kg)			
Birth	3.1±0.4	3.2±0.4	<0.001
1.5 y	10.7±1.2	11.7±1.6	<0.001
3.5 y	14.5±1.6	16.9±2.1	<0.001
5 y	16.6±1.7	20.6±3.1	<0.001
Increment of weight (kg)			
Birth - 1.5 y	7.6±1.2	8.4±1.5	<0.001
1.5 y - 3.5 y	3.9±1.0	5.3±1.6	<0.001
3.5 y - 5 y	2.1±1.2	3.7±2.2	<0.001
Weight z-score			
Birth	0.17±0.91	0.59±0.95	<0.001
1.5 y	0.13±1.01	0.99±1.37	<0.001
3.5 y	-0.10±0.86	1.25±1.17	<0.001
5 y	0.01±0.83	1.92±1.47	<0.001
Increment of weight z-score			
Birth - 1.5 y	-0.04±1.19	0.40±1.31	<0.001
1.5 y - 3.5 y	-0.23±0.64	0.26±1.03	<0.001
3.5 y – 5 y	0.12±0.61	0.67±1.05	<0.001
BMI (kg/m²)			
Birth	12.7±1.5	13.1±1.2	<0.01
1.5 y	16.3±2.0	17.7±2.0	<0.001
3.5 y	15.6±1.6	17.6±1.1	<0.001
5 y	15.3±0.9	18.2±1.3	<0.001
Increment of BMI (kg/m²)			
Birth - 1.5 y	3.5±2.5	4.6±1.8	<0.001
1.5 y - 3.5 y	-0.7±1.8	-0.1±1.8	<0.01
3.5 y - 5 y	-0.3±1.4	0.6±1.1	<0.001
BMI% tile			
Birth	51.1±27.9	61.9±26.3	<0.001
1.5 y	50.6±26.7	78.6±19.8	<0.001
3.5 y	52.8±24.7	90.7±9.2	<0.001
5 y	48.1±23.6	95.0±3.1	<0.001
Increment of BMI% tile			
Birth - 1.5 y	-0.4±35.3	16.7±25.3	<0.001
1.5 y - 3.5 y	2.2±21.8	12.1±18.9	<0.001
3.5 y - 5 y	-4.8±18.3	4.3±8.7	<0.001

†Data represent means±SD.
*Differences in the physical characteristics among the 2 groups were examined by Student t-test.

children in both genders. On the other hand, the significant differences in increments of actual height and their z-scores in two groups were only seen during 1.5-3.5 years in both genders (actual height: $p<0.01$, height z-score: $p<0.05$ for boys; actual height and height z-score: $p<0.01$ for girls).

The association of height or weight growth velocity with the risk of obesity at 5 years of age

In order to examine the effect of height or weight changes on the prevalence of obesity at 5 years of age, we calculated the growth velocity during birth-1.5 years, 1.5-3.5 years, and 3.5-5 years separately. We classified these figures into quartiles. In this analysis, we only used z-scores considering the fact that the growth in infancy or early

Table 2. Comparison of the physical characteristics at each time point based on the body status at 5 years in girls

	Body status at 5 years		p-value*
	Normal-weight (n=1203)	Obese (n=71)	
Height (cm)			
Birth	48.4±2.2†	48.7±2.0	0.16
1.5 y	79.7±4.5	79.7±6.4	0.47
3.5 y	95.8±4.2	97.4±4.3	<0.01
5 y	104±4.7	105±5.2	<0.05
Increment of height (cm)			
Birth - 1.5 y	31.2±4.6	31.0±6.5	0.35
1.5 y - 3.5 y	16.1±4.0	17.7±5.0	<0.01
3.5 y - 5 y	7.7±3.7	7.1±3.7	0.11
Height z-score			
Birth	0.02±1.05	0.14±0.94	0.16
1.5 y	0.10±1.68	0.12±2.38	0.47
3.5 y	-0.03±1.18	0.41±1.19	<0.01
5 y	0.18±1.17	0.43±1.31	<0.05
Increment of height z-score			
Birth - 1.5 y	0.08±1.79	-0.03±2.44	0.31
1.5 y - 3.5 y	-0.13±1.36	0.29±1.87	<0.01
3.5 y - 5 y	0.20±0.98	0.02±0.95	0.06
Weight (kg)			
Birth	3.0±0.3	3.1±0.4	<0.001
1.5 y	10.1±1.2	11.3±1.0	<0.001
3.5 y	14.2±1.5	16.7±1.7	<0.001
5 y	16.4±1.8	19.9±2.7	<0.001
Increment of weight (kg)			
Birth - 1.5 y	7.2±1.2	8.1±0.9	<0.001
1.5 y - 3.5 y	4.1±1.1	5.4±1.2	<0.001
3.5 y - 5 y	2.2±1.1	3.3±1.8	<0.001
Weight z-score			
Birth	-0.03±0.87	0.32±0.94	<0.001
1.5 y	0.25±1.20	1.37±1.03	<0.001
3.5 y	0.08±0.90	1.50±0.99	<0.001
5 y	0.05±0.83	1.66±1.23	<0.001
Increment of weight z-score			
Birth - 1.5 y	0.28±1.29	1.05±1.07	<0.001
1.5 y - 3.5 y	-0.17±0.83	0.13±0.82	<0.01
3.5 y - 5 y	-0.03±0.57	0.15±0.82	<0.01
BMI (kg/m²)			
Birth	12.8±1.6	13.1±1.0	<0.05
1.5 y	16.0±2.0	18.1±4.7	<0.001
3.5 y	15.5±1.0	17.6±1.3	<0.001
5 y	15.3±0.9	18.2±1.1	<0.001
Increment of BMI (kg/m²)			
Birth - 1.5 y	3.2±2.5	5.0±4.7	<0.001
1.5 y - 3.5 y	-0.5±1.9	-0.6±4.1	0.37
3.5 y - 5 y	-0.2±0.7	0.6±1.1	<0.001
BMI% tile			
Birth	52.3±27.9	64.8±26.3	<0.001
1.5 y	54.9±27.2	83.6±19.1	<0.001
3.5 y	53.6±24.9	90.0±9.0	<0.001
5 y	49.2±22.9	94.3±2.9	<0.001
Increment of BMI% tile			
Birth - 1.5 y	2.7±35.4	18.8±28.3	<0.001
1.5 y - 3.5 y	-1.3±22.2	6.4±16.9	<0.001
3.5 y - 5 y	-4.5±16.6	4.3±8.1	<0.001

†Data represent means±SD.
*Differences in the physical characteristics among the 2 groups were examined by Student t-test.

childhood is not linear. Increased trends of the obesity prevalence at 5 years of age with an increased velocity of weight were observed at every observation period in both boys (Table 3) and girls (Table 4). In contrast, an increased velocity of height had a negative effect on the obesity prevalence during only the period of 3.5-5 years in both boys (Table 3) and girls (Table 4).

Longitudinal follow-up of the number of obese children from birth to 5 years of age

Table 5 summarizes the follow-up data of each child's incidence and remission of obesity from birth to 5 years of age. The prevalence of obesity at 5 years of age in children who were obese at birth was 10.9% in boys and 10.4% in girls. If obesity was noted at later ages, i.e. 1.5 or 3.5 years, the prevalence of obesity at 5 years of age tended to increase strikingly. In addition, the differences of prevalence between obese-obese and normal weight-obese children in three different periods, i.e. birth-5 years, 1.5-5 years, or 3.5-5 years were all significant in both genders.

Association of parental obesity with obesity in children at 5 years of age

After excluding 666 children, because they were thin at 5 years of age, or the height and weight of one of their parents were not provided in the questionnaire, 2012 children (1,010 boys, 1,002 girls) were enrolled in the analysis. As shown in Table 6, a significant association of obesity prevalence was found between both parents and daughters, and between mothers and daughters, but the significant association was not found between fathers and daughters. In contrast, there was no association of any types of parental obesity and sons' obesity. Attributable risks between each pair were also shown in Table 6.

DISCUSSION

Obesity is a potential risk factor for lifestyle-related diseases in adulthood.[27] Since adult obesity may begin in childhood, an investigation of the time and causes of the appearance of obesity in children is important. Although obesity occurring at elementary school children or adolescents is a mainstream research,[10,28] there have been several studies reporting the prevalence of overweight or obesity in infancy and early childhood.[29-32] Lo et al demonstrated that obesity and severe obesity becomes evident as early as age 3-5 years.[29] In a longitudinal study, Larsen et al reported a strong association between overweight or obesity at 3 and 5 years of age.[30] However, the problem is that the results of the analysis were highly dependent upon the definition of overweight or obesity.[31,32] For ex-ample, the prevalence of obesity in pre-

Table 3. The association of height or weight growth velocity with the risk of obesity at 5 years of age in boys

	No.	Body status at 5 years		OR (95% CI)‡	*p*-value*
		Obese (%)	Not-obese (%)		
Increment of height z-scores / year†					
Birth-1.5 y					0.59
Quartile 1	335	15 (4.5)	320 (95.5)	1.00	
Quartile 2	341	20 (5.9)	321 (94.1)	1.33 (0.67-2.64)	
Quartile 3	346	21 (6.1)	325 (93.9)	1.38 (0.70-2.72)	
Quartile 4	331	23 (6.9)	308 (93.1)	1.59 (0.82-3.11)	
1.5-3.5 y					0.53
Quartile 1	339	15 (4.4)	324 (95.6)	1.00	
Quartile 2	338	20 (5.9)	318 (94.1)	1.36 (0.68-2.70)	
Quartile 3	338	20 (5.9)	318 (94.1)	1.36 (0.68-2.70)	
Quartile 4	338	24 (7.1)	314 (92.9)	1.65 (0.85-3.21)	
3.5-5 y					<0.05
Quartile 1	339	21 (6.2)	318 (93.8)	1.00	
Quartile 2	337	19 (5.6)	318 (94.4)	0.90 (0.48-1.72)	
Quartile 3	338	11 (3.3)	327 (96.7)	0.51 (0.24-1.07)	
Quartile 4	339	28 (8.3)	311 (91.7)	1.36 (0.76-2.45)	
Increment of weight z-scores / year†					
Birth-1.5 y					<0.001
Quartile 1	339	7 (2.1)	332 (97.9)	1.00	
Quartile 2	338	14 (4.1)	324 (95.9)	2.05 (0.82-5.14)	
Quartile 3	338	28 (8.3)	310 (91.7)	4.28 (1.84-9.95)	
Quartile 4	338	30 (8.9)	308 (91.1)	4.62 (2.00-10.7)	
1.5-3.5 y					<0.001
Quartile 1	328	11 (3.4)	317 (96.6)	1.00	
Quartile 2	363	9 (2.5)	354 (97.5)	0.73 (0.30-1.79)	
Quartile 3	324	20 (6.2)	304 (93.8)	1.90 (0.89-4.02)	
Quartile 4	338	39 (11.5)	299 (89.5)	3.76 (1.89-7.48)	
3.5-5 y					<0.001
Quartile 1	338	11 (3.3)	327 (96.7)	1.00	
Quartile 2	336	13 (3.9)	323 (96.1)	1.20 (0.53-2.71)	
Quartile 3	348	15 (4.3)	333 (95.7)	1.34 (0.61-2.96)	
Quartile 4	331	40 (12.1)	291 (87.9)	4.09 (2.06-8.11)	

†Increments of height or weight z-score between birth and 1.5 years, 1.5 and 3.5 years or 3.5 and 5 years were divided by 1.5, 2, or 1.5 years, respectively. ‡ORs and 95% CI are shown. *Chi-square test.

Table 4. The association of height or weight growth velocity with the risk of obesity at 5 years of age in girls

	No.	Body status at 5 years		OR (95% CI)‡	*p*-value*
		Obese (%)	Not-obese (%)		
Increment of height z-scores / year†					
Birth-1.5 y					0.63
Quartile 1	333	17 (5.1)	316 (94.9)	1.00	
Quartile 2	326	14 (4.3)	312 (95.7)	0.83 (0.40-1.72)	
Quartile 3	335	22 (6.6)	313 (93.4)	1.31 (0.68-2.51)	
Quartile 4	331	18 (5.4)	313 (94.6)	1.07 (0.54-2.11)	
1.5-3.5 y					0.54
Quartile 1	332	13 (3.9)	319 (96.1)	1.00	
Quartile 2	329	12 (3.6)	317 (96.4)	0.93 (0.42-2.07)	
Quartile 3	329	17 (5.2)	312 (94.8)	1.34 (0.64-2.80)	
Quartile 4	335	29 (8.7)	306 (91.3)	2.33 (1.19-4.56)	
3.5-5 y					<0.01
Quartile 1	331	27 (8.2)	304 (91.8)	1.00	
Quartile 2	332	18 (5.4)	314 (94.6)	0.65 (0.35-1.20)	
Quartile 3	328	6 (1.8)	322 (98.2)	0.21 (0.09-0.52)	
Quartile 4	334	20 (6.0)	314 (94.0)	0.72 (0.39-1.31)	
Increment of weight z-score / year†					
Birth-1.5 y					<0.001
Quartile 1	332	7 (2.1)	325 (97.9)	1.00	
Quartile 2	332	11 (3.3)	321 (96.7)	1.59 (0.61-4.16)	
Quartile 3	329	17 (5.2)	312 (94.8)	2.53 (1.03-6.18)	
Quartile 4	332	36 (10.8)	296 (89.2)	5.65 (2.48-12.9)	
1.5-3.5 y					<0.001
Quartile 1	334	18 (5.4)	316 (94.6)	1.00	
Quartile 2	318	11 (3.5)	307 (96.5)	0.63 (0.29-1.35)	
Quartile 3	345	7 (2.0)	338 (98.0)	0.36 (0.15-0.88)	
Quartile 4	328	35 (10.7)	293 (89.3)	2.10 (1.16-3.78)	
3.5-5 y					<0.05
Quartile 1	328	18 (5.5)	310 (94.5)	1.00	
Quartile 2	336	9 (2.7)	327 (97.3)	0.47 (0.21-1.07)	
Quartile 3	330	16 (4.8)	314 (95.2)	0.88 (0.44-1.75)	
Quartile 4	331	28 (8.5)	303 (91.5)	1.59 (0.86-2.94)	

†Increments of height or weight z-score between birth and 1.5 years, 1.5 and 3.5 years or 3.5 and 5 years were divided by 1.5, 2, or 1.5, respectively. ‡ORs and 95% CI are shown. *Chi-square test.

Table 5. Longitudinal follow-up of the number of obese children from birth to 5 years of age

		No.	Weight status at 5 years		OR (95% CI)†	*p*-value‡
			Obese (%)	Not-obese (%)		
Boys						
Birth	Not-obese	1225	65 (5.3)	1160 (94.7)	1.00	<0.01
	Obese	128	14 (10.9)	114 (89.1)	2.19 (1.19-4.03)	
1.5 y	Not-obese	1229	51 (4.1)	1178 (95.9)	1.00	<0.001
	Obese	124	28 (22.6)	96 (77.4)	6.74 (4.06-11.2)	
3.5 y	Not-obese	1237	28 (2.3)	1209 (97.7)	1.00	<0.001
	Obese	116	51 (44.0)	65 (56.0)	33.88 (20.1-57.2)	
Girls						
Birth	Not-obese	1181	56 (4.7)	1125 (95.3)	1.00	<0.01
	Obese	144	15 (10.4)	129 (89.6)	2.34 (1.28-4.25)	
1.5 y	Not-obese	1151	31 (2.7)	1120 (97.3)	1.00	<0.001
	Obese	174	40 (23.0)	134 (77.0)	10.8 (6.53-17.8)	
3.5 y	Not-obese	1216	25 (2.1)	1191 (97.9)	1.00	<0.001
	Obese	109	46 (42.2)	63 (57.8)	34.8 (20.1-60.2)	
Total						
Birth	Not-obese	2406	121 (5.0)	2285 (95.0)	1.00	<0.001
	Obese	272	29 (10.7)	243 (89.3)	2.25 (1.47-3.45)	
1.5 y	Not-obese	2380	82 (3.4)	2298 (96.6)	1.00	<0.001
	Obese	298	68 (22.8)	230 (77.2)	8.29 (5.85-11.74)	
3.5 y	Not-obese	2453	53 (2.2)	2400 (97.8)	1.00	<0.001
	Obese	225	97 (43.1)	128 (56.9)	34.3 (23.5-50.1)	

†ORs and 95% CI are shown.
‡Chi-square test.

Table 6. Relation of parental obesity to obesity in their children at 5 years

		No.	Body status at 5 years		OR (95% CI)*	*p*-value**	Attributable risk#
			Obese (%)	Normal-weight (%)			
Both parents							
Sons	Not-obese	983	59 (6.0)	924 (94.0)	1.00	0.62	-2.3
	Obese	27	1 (3.7)	26 (96.3)	0.60 (0.08-4.51)		
Daughters	Not-obese	975	56 (5.7)	919 (94.3)	1.00	<0.001	16.5
	Obese	27	6 (22.2)	21 (77.8)	4.69 (1.82-12.1)		
Total	Not-obese	1958	115 (5.9)	1843 (94.1)	1.00	<0.05	7.1
	Obese	54	7 (13.0)	47 (87.0)	2.39 (1.06-5.40)		
Mother							
Sons	Not-obese	960	57 (5.9)	903 (94.1)	1.00	0.99	0.1
	Obese	50	3 (6.0)	47 (94.0)	1.01 (0.31-3.35)		
Daughters	Not-obese	930	51 (5.5)	879 (94.5)	1.00	<0.001	9.8
	Obese	72	11 (15.3)	61 (84.7)	3.11 (1.54-6.27)		
Total	Not-obese	1890	108 (5.7)	1782 (94.3)	1.00	<0.01	5.8
	Obese	122	14 (11.5)	108 (88.5)	2.14 (1.19-3.86)		
Father							
Sons	Not-obese	734	41 (5.6)	693 (94.4)	1.00	0.44	0.7
	Obese	276	19 (6.9)	257 (93.1)	1.25 (0.71-2.19)		
Daughters	Not-obese	730	41 (5.6)	689 (94.4)	1.00	0.22	2.1
	Obese	272	21 (7.7)	251 (92.3)	1.41 (0.81-2.43)		
Total	Not-obese	1464	82 (5.6)	1382 (94.4)	1.00	0.16	1.7
	Obese	548	40 (7.3)	508 (92.7)	1.33 (0.90-1.96)		

2012 children (1010 sons, 1002 daughters) and their parents were analyzed.
*ORs and 95% CI are shown.
**Chi-square test
#Attributable risks were calculated as per 100 children.

school children with an average age of 5.02 years was reported as 11.7%, 6.1%, and 13.8% by the criteria of the Centre for Disease Control or the International Obesity Task Force and the World Health Organization, respectively.[32] Notably, these criteria are based primarily on children from Western children from Western countries. Since it is well known that the physical characteristics of the population in these countries are different from those of East Asian populations,[23] we used Japanese criteria for the present analysis.[24]

In the present study, we demonstrated that the prevalence of obesity at 5 years of age was 5.6% without any significant difference between genders. This value is almost identical to that reported in the recent Japanese large cohort survey.[33] The prevalence was also found to decrease with age, especially from 3.5 years of age. The reason for this observation can’t be clarified at present, since our study only focused on demographic data without investigating any related socio-economic or nutritional factors.[33,34] However, a significantly higher increment of actual height and their z-scores during 1.5-3.5 years may compensate partly an increase of BMI in obese children, and thus play a role of a decrease in overall obesity prevalence at 3.5 years of age. The longitudinal follow-up survey of BMI in each child explored the prevalence of incidence and remission of obesity during the observation period. Consequently, it was found that approximately one-tenth of obese children at birth were still obese at 5 years of age. The prevalence rose at the rate of almost double that of children who were obese at the time of 1.5 years and 3.5 years. These data indicate that an earlier intervention is important for reducing the prevalence of obesity at 5 years of age.

In 1970, Eid first stated that the rapidity of weight gain in infancy is a good guide for determining the risk of overweight in later childhood.[35] Thereafter, a number of studies have reported the association between rapid weight gain in infancy or early childhood and overweight or obesity in later childhood or adulthood.[12-14] However, there is a debate regarding the critical period when the effect of rapid weight gain is most strongly associated with obesity in later childhood or adulthood. Taveras et al demonstrated that upward crossing of 2 weight-for-length percentiles in the first 6 months of life is associated with obesity at 5 and 10 years of age.[13] In a meta-analysis of individual-level data from 10 cohort studies, weight gain between birth and 1 year of age was shown to be associated with subsequent obesity in childhood.[14] Finally, Ong and Loos reported importance of rapid weight gain up to age of 2 years in a systematic review of 21 separate studies.[12] In contrast, Kinra et al postulated that obesity risk increased gradually over the perinatal and postnatal periods, rather than there being a prenatal or early postnatal critical window.[36] Our present retrospective tracking study revealed that the increments of weight z-score in obese 5-years-old was consistently greater than those of normal-weight infants from birth to 5 years of age. The calculation of the velocity in the weight growth in every observation period turned out to be significantly associated with an increased obesity risk at 5 years of age. In contrast, an increased velocity of height growth only in 3.5-5 years was inversely associated with the obesity prevalence. These results together may indicate the importance of weight gain velocity in the occurrence of obesity in early childhood. However, since the outcome was evaluated at 5 years of age, a longer longitudinal study up to later childhood is essential.

Parental obesity has been shown to be an apparent risk factor for children's obesity.[15,16] An interesting issue is whether maternal or paternal obesity has a greater effect on child obesity. A number of studies have suggested that there are more positive associations between maternal and child obesity, implying that the intrauterine environment and/or maternal lifestyle may play a substantial role in determining child body status.[18-20] Our present results which showed a positive association of both parents-daughters or mother-daughters obesity are partly consistent with these previous reports. However, such an association was not found in sons. On the other hand, the present investigation failed to detect any association of paternal obesity with child obesity at 5 years of age in both genders, which is in contrast with previous studies.[17-20] The reasons for these findings are uncertain at present, but we may speculate that this is partly due to mothers being responsible for more early childhood care particularly in Japan and having a greater influence on food purchasing and preparation. In addition, the effects of parental weight on the prevalence of obesity in children were different depending upon children's ages. Several investigators reported that the association between maternal BMI and offspring weight or BMI was evident from birth to 3 years.[37,38] Safer et al, on the other hand, demonstrated that significant correlations between parental and child obesity were not observed until the age of 7.[39] Since our present study was carried out at children's age of 5 years, we can't exclude the possibility that the association may become apparent at later ages of children.

There are several limitations in the present study. First, since this study was retrospective, only approximately 30% of kindergartens and nursery schools participated. Second, the area of investigation was restricted to Nara Prefecture. Considering the fact that obesity rates differ substantially among different districts in Japan,[3] further research should be planned to gather and analyze data from all areas of Japan. Third, because early childhood obesity is an important problem that must be addressed in order to avoid adverse effects related to obesity during adulthood, a longer longitudinal study from birth to later childhood or adulthood should be carried out. The strengths of the present study were two-fold. First, although the study was retrospective, the children's height and weight were obtained from mother-child health notebooks. In Japan, a regular health check for children is carried out by experts at the age of 1.5, and 3.5 years old, and the results are recorded in these notebooks. Therefore, the records are thought to be fairly accurate. Notably, the possibility that parent-reported height and weight of their children may become the sources of bias was reported.[40] Second, we classified all children into 3 groups (thin, normal-weight, obese) at first, and in the analysis, removed children with thinness. Although there is a study excluding underweight children from the analysis,[28] in most previous studies, the characteristics of obese children have been compared with those of non-obese children including thin children.[16,33]

In conclusion, the evidence provided here suggests that it is important to pay attention to changes in body weight continuously from birth to avoid obesity at 5 years of age. Considering the association of obesity between mothers and daughters, effective programs of preventive intervention of obesity are potentially important, especially for mothers.

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AUTHOR DISCLOSURES

The authors declare no competing financial interests.

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Original Article

Retrospective tracking of young obese children back to birth in Japan: special attention to the relationship with parental obesity

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回顾性追溯日本肥胖幼儿到出生：特别关注其与父母肥胖的关系

目的：肥胖从儿童期持续到成年期的比例很高，然而，关于幼儿肥胖的纵向研究仍然有限。本研究旨在与正常体重儿童相比，追踪肥胖幼儿到出生，并研究其与父母肥胖的关系。**方法**：本研究纳入了日本奈良地区的学前班或幼儿园的 2,678 名（男孩 1,353 名）幼儿。通过问卷获得了儿童和父母目前的身高和体重，通过母子的健康笔记本所记录的资料获得儿童出生、1.5 岁和 3.5 岁时的身高和体重。分别用体质指数（BMI）大于或等于日本儿童参考数据的 90^{th} 和 25（kg/m²）作为儿童和父母肥胖的判断标准。**结果**：儿童总的肥胖患病率从出生时的 10.2%下降到 5 岁时的 5.6%。在回顾性追踪中，5 岁时肥胖的儿童体重的 Z 值和 BMI 的百分位值从出生一直显著高于体重正常的儿童。出生到 1.5 岁、1.5-3.5 岁和 3.5-5 岁这三个时期体重的增加速度用他们的 Z 值进行校正后，与 5 岁时肥胖的风险增加显著相关。在父母与子女肥胖相关性分析中，仅发现母亲肥胖与女儿肥胖相关。**结论**：从婴儿早期管理体重对减少 5 岁儿童肥胖的发生很重要。母亲肥胖者需要更多地关注其女儿。

关键词：体质指数、肥胖、父母肥胖、追踪、幼儿