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Original Article

Relationship between Eating Quickly and Overweight: A Cohort Study of Schoolchildren in Japan

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Several cross-sectional studies have shown that eating quickly is associated with overweight in children and adolescents. However, few cohort studies have examined this relationship. Here we investigated the relationship between eating quickly and overweight in a cohort study of fourth-grade schoolchildren (aged 9 or 10 years) who attended elementary schools in Ina-town, Japan. The children were followed for 3 years from 2001-2004 (at baseline) to 2004-2007. A questionnaire survey including information about eating speed (fast, medium, or slow) was administered, and height and weight measurements were obtained at baseline and follow-up. Overweight was defined according to the body mass index cutoff points proposed by the International Obesity Task Force. We used a Poisson regression model to examine the association between eating quickly at baseline and being overweight 3 years later. Data from 934 non-overweight children (465 boys, 469 girls) were analyzed. Eating quickly was not significantly associated with being overweight in the boys, whereas it was significantly associated with being overweight in the girls. Our analysis indicates that among girls, eating quickly leads to overweight, and that the modification of eating quickly could help prevent overweight in adolescents.

Key words: eating quickly, overweight, schoolchildren, cohort study

Childhood overweight and obesity is an important and increasingly prevalent public health problem worldwide [1]. Overweight/obesity in children and adolescents can result in various adverse health outcomes such as type 2 diabetes, hypertension, dyslipidemia, and obstructive sleep apnea [2]. Moreover, adults who were obese children have an increased risk on morbidity and mortality independent of their adult weight [3]. The prevention of overweight and obesity in children and adolescents is therefore critical for the health of children, adolescents, and adults.

It has been reported that children and adolescents become overweight or obese because of an imbalance between energy intake and expenditure [4]. Energy intake is associated with eating behaviors, of which the rate of eating was shown to be positively associated with energy intake [5]. Eating speed, which is related to all meals (breakfast, lunch, and dinner), is a modifiable factor. Therefore, eating speed plays an important role in energy intake and is a key factor for the prevention of overweight or obesity among children and adolescents.

To date, several studies have shown that overweight/obesity in children and adolescents is associated with eating quickly [5-7]. Murakami *et al.* reported that a higher rate of eating was positively associated with an

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increased risk of overweight/obesity in children and adolescents [5]. Lin *et al.* reported that higher eating speed was associated with overweight/obese in preschool children [6]. Sun *et al.* showed that eating quickly was associated with adolescent overweight/obesity [7]. However, these studies were cross-sectional, rendering it difficult to examine the causal relationship between eating quickly and overweight/obesity. If eating quickly is a risk factor of overweight/obesity, then the modification of eating quickly in childhood could decrease the risk of being overweight/obese later in life. It is thus critical to investigate this causal relationship in a cohort study. We previously investigated the relationship between eating quickly and anthropometric variables [8-10], but we have not evaluated the relationship between eating quickly and overweight/obesity after adjusting for lifestyle factors (e.g., exercise, snack, and sleep) reported to be associated with overweight/obesity [7, 11, 12] in a cohort study.

Accordingly, we investigated the causal relationship between eating quickly and overweight/obesity after adjusting for lifestyle factors in a cohort study of schoolchildren in Japan.

Subjects and Methods

The town of Ina is located in Saitama Prefecture, Japan. The town was formerly an agricultural area but has been urbanized recently [INA TOWN. http://www.town.saitama-ina.lg.jp.e.gw.hp.transer.com/ (accessed June 30, 2017.)]. The population is approx. 44,000 and the number of live births in 2015 was 197 boys and 197 girls [INA TOWN. http://www.town.saitama-ina.lg.jp.e.gw.hp.transer.com/ (accessed June 30, 2017.)]. The town had performed a health checkup program for fourth graders and seventh graders as a part of its community health services. The program included anthropometric measurements and a questionnaire survey. The present study was conducted based on that program.

Study subjects. The subjects were all fourth grade schoolchildren (aged 9 or 10 years) who attended elementary schools in Ina-town during the years 2001-2004. In this cohort study, the participants were followed for 3 years from 2001-2004 (at baseline) to 2004-2007. Informed consent was obtained from the parent or guardian of each child. The study was approved by the Medical Ethics Committee of Showa University School of Medicine (approval no. 127).

Of 1,379 subjects (2001: n = 316, 2002: n = 325, 2003: n = 353, 2004: n = 385), 1,370 children participated in this study and underwent anthropometric measurements and the questionnaire survey at baseline (September 2001-2004) (participation rate: 99.3%). Among these 1,370 participants (2001: n = 316, 2002: n = 316, 2003: n = 353, 2004: n = 385), 1,244 participants (2004: n = 289, 2005: n = 288, 2006: n = 323, 2007: n = 344) underwent follow-up anthropometric measurements and the questionnaire survey 3 years later (September 2004-2007) (follow-up rate from 2001-2004 to 2004-2007: 90.8%, from 2001 to 2004: 91.5%, from 2002 to 2005: 91.1%, from 2003 to 2006: 91.5% from 2004 to 2007: 89.4%). We excluded 310 of the children who underwent the follow-up measurements and the survey from the analysis, due to missing data (n = 105) and overweight status (obese was included in overweight) at fourth grade (n = 205), which was defined by the body mass index (BMI) cutoff points proposed by the International Obesity Task Force [13], because the objective of this cohort study was to examine the relationship between eating quickly and becoming overweight. Thus, the data of 934 non-overweight children (465 boys, 469 girls) were analyzed (Fig. 1).

Anthropometric measurements. Anthropometric measurements of the participants were performed at baseline (September 2001-2004) and 3 years later (September 2004-2007).

The measurements for height and weight were carried out by trained school nurses/doctors in the school's infirmary or in a designated room to ensure that the participant's privacy was protected during the procedures. Participants were asked to remove shoes and socks before the measurements. During the measurements, they wore light clothing in a standing position. Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively. BMI was calculated as weight (kg) divided by height (m^2).

All anthropometric measurements were conducted using the same procedures at baseline and 3 years later.

Questionnaire survey. A questionnaire survey was also administered to the children at baseline (September 2001-2004) and 3 years later (September 2004-2007). The following information was collected from each participant: sex, age, exercise other than physical education class (daily, sometimes, or none), snacking after dinner (always, sometimes, seldom,

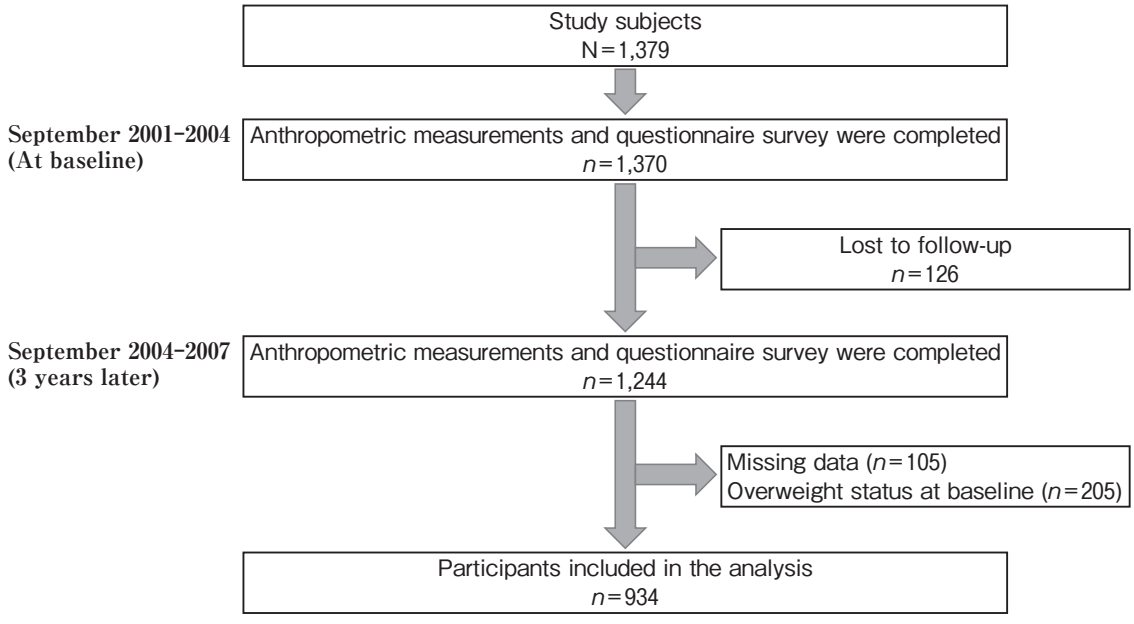

Fig. 1 Flow diagram of study participants included in the analysis.

none), and eating speed. Information regarding eating speed was obtained according to three qualitative categories (fast, medium, or slow) [14] from the question: "How fast is your eating speed compared to others?" The parent or guardian of each participant filled in the questionnaire about the participant's wake-up time and bedtime. The participant's sleep duration was calculated from the wake-up time and bedtime.

Data analysis. According to previous studies [14-16], eating speed was categorized into 2 groups: eating quickly (fast) and not eating quickly (medium or slow). Data are presented as median (25th percentile, 75th percentile) for continuous variables or number (%) for categorical variables. The chi-square test or Fisher's exact test was used to compare lifestyles at baseline between children who were overweight 3 years later and those who were not overweight 3 years later.

We used a Poisson regression model with a robust error variance to calculate the risk ratio (RR) and 95% confidence interval (CI) of eating quickly at baseline for being overweight 3 years later. Based on previous studies [7,11,12], the following variables reported to be associated with overweight and obesity were adjusted for in the model: sex, exercise, snacking after dinner, and sleep duration. In the analysis for each sex, sex was excluded from the model.

A p-value < 0.05 was considered significant. All statistical analyses were performed using Statistical Analysis System ver. 9.4 software (SAS, Cary, NC, USA).

Results

Table 1 summarizes the baseline characteristics of the participants. The median age of all participants was 9.0 years, and the proportion of overweight at baseline was 18.5%. Table 2 summarizes the characteristics of the participants included in the analysis. The height at the 3-year follow-up point tended to be higher in boys compared to the girls. The BMI at baseline was likely to be higher in the boys than in the girls, whereas the BMI at the 3-year follow-up point was likely to be higher in the girls than in the boys. The proportion of children who had become overweight at the 3-year follow-up point was 2.6% among the total participants (boys: 1.1%, girls: 4.1%).

The associations between lifestyle factors at baseline and being overweight at the 3-year follow-up point among the total participants are shown in Table 3. The proportion of children who ate quickly was higher in the overweight group compared the non-overweight group, although the difference was not significant. There was a significant difference in the level of exercise (daily, sometimes, none) between the non-overweight and

Table 1 Baseline characteristics of all participants and excluded participants due to loss to follow-up or missing data

	All participants (N = 1,370)	Loss to follow-up (n = 126)	Missing data (n = 105)
Sex, *n* (%)			
Boys	712 (52.0)	71 (56.3)	53 (50.5)
Girls	658 (48.0)	55 (43.7)	52 (49.5)
Age (years)	9.0 (9.0, 10.0)	9.0 (9.0, 10.0)	9.0 (9.0, 10.0)
Height (cm)	135.5 (131.6, 139.4)	134.9 (131.0, 139.4)	135.5 (131.1, 140.7)
Weight (kg)	30.7 (27.2, 35.5)	31.0 (27.3, 36.3)	31.8 (27.7, 39.0)
BMI (kg/m^2)	16.6 (15.4, 18.6)	16.7 (15.6, 18.8)	17.1 (15.9, 19.5)
BMI z-score	−0.53 (−1.35, 0.45)	0.33 (−0.43, 1.25)	−0.30 (−1.06, 0.63)
Overweight, *n* (%)	254 (18.5)	24 (19.0)	25 (23.8)

BMI, body mass index.
Values are expressed as the median (25th percentile, 75th percentile) except where *n* (%) is indicated.

overweight groups. In contrast, no significant differences between the non-overweight and overweight groups were observed for snacking after dinner, wake-up time, bedtime, or sleep duration.

Among the boys, there were no significant differences between lifestyle factors at baseline and being overweight 3 years later (Table 3). In contrast, the proportion of girls who ate quickly was significantly higher in the overweight group than in the non-overweight group (Table 3). Among the girls, no significant differences between the overweight and non-overweight groups were found for exercise, snacking after dinner, wake-up time, bedtime, or sleep duration.

We calculated the crude and adjusted RRs and their 95%CIs for eating quickly at baseline and then being overweight 3 years later (Table 4). The crude RR (95%CI) of eating quickly was 2.37 (0.96-5.86) among the total participants. The RR of the girls was 3.77 (95%CI: 1.42-10.01). When compared to the total participants who daily exercised, the crude RRs were 2.13 (0.68-6.64) in those who sometimes exercised and 5.05 (1.80-14.16) in those who did not exercise. The RR in the total participants who always or sometimes snacked after dinner was 1.56 (0.69-3.54). Compared with the total participants with sleep duration ≥ 10 h, the crude RRs were 1.17 (0.34-4.01) in those with 9.0-9.9 h and 1.39 (0.37-5.29) in those with < 9.0 h. After adjusting for sex, exercise, snacking after dinner, and sleep duration, eating quickly significantly increased the RR (3.65, 95%CI: 1.52-8.76, $p = 0.004$) for being overweight.

When the analysis was limited to boys, eating quickly increased the RR, although the RR was not significant (adjusted RR: 4.27, 95%CI: 0.76-24.07, $p = 0.100$). In contrast, a significant association was observed in the girls (adjusted RR: 3.69, 95%CI: 1.33-10.25, $p = 0.012$).

Discussion

We prospectively investigated the relationship between eating quickly and overweight by adjusting for lifestyle factors among schoolchildren in a cohort study. Our analyses demonstrated that eating quickly during fourth grade was associated with the increased risk of being overweight at seventh grade. To our knowledge, this is the first cohort study to investigate the association between eating quickly and overweight among schoolchildren in Japan. Our results are consistent with recent cross-sectional studies of children and adolescents [5-7]. In addition, a previous cohort study of university students showed that eating quickly may predict the risk of overweight [17]. These studies' results indicate that our present findings are reasonable.

Most of these studies [5, 7, 17] were conducted in Japan. In Japan, the term "*Hara hachi bu*" has been used for more than 300 years and it is popular even now [18]. *Hara hachi bu*, which means eating until one is 80% full, is a traditional practice that involves an intuitive approach to controlling dietary intake by mindfully stopping eating before feeling full, not by external factors [18]. Therefore, *Hara hachi bu* contributes to the prevention of overeating. Because eating quickly may cause overeating before the stomach senses fullness [19], one's eating speed might affect *Hara hachi bu*. Accordingly, eating speed may have received more attention in Japan compared to the other countries.

Table 2 Characteristics of study participants included in the analysis

	At baseline			3 years later		
	Total ($n=934$)	Boys ($n=465$)	Girls ($n=469$)	Total ($n=934$)	Boys ($n=465$)	Girls ($n=469$)
Age (years)	9.0 (9.0, 10.0)	9.0 (9.0, 10.0)	9.0 (9.0, 10.0)	12.0 (12.0, 13.0)	12.0 (12.0, 13.0)	12.0 (12.0, 13.0)
Height (cm)	135.1 (131.1, 138.7)	135.1 (131.4, 138.4)	135.0 (130.9, 139.2)	153.2 (148.6, 158.0)	153.8 (148.4, 159.3)	153.0 (148.8, 156.8)
Weight (kg)	29.2 (26.6, 32.4)	29.5 (27.0, 32.5)	29.0 (26.2, 32.3)	41.6 (37.4, 46.2)	41.5 (36.9, 45.9)	41.8 (37.8, 46.2)
BMI (kg/m^2)	16.1 (15.1, 17.3)	16.2 (15.3, 17.4)	16.0 (15.0, 17.1)	17.6 (16.3, 18.9)	17.4 (16.3, 18.6)	17.8 (16.5, 19.2)
BMI z-score	−0.95 (−1.68, −0.28)	−0.85 (−1.59, −0.20)	−1.05 (−1.71, −0.38)	−0.11 (−0.80, 0.50)	−0.17 (−0.82, 0.43)	−0.06 (−0.79, −0.57)
Overweight, *n* (%)	0 (0)	0 (0)	0 (0)	24 (2.6)	5 (1.1)	19 (4.1)

BMI, body mass index.
Values are expressed as the median (25th percentile, 75th percentile) except where *n* (%) is indicated.

Table 3 Associations between lifestyle factors at baseline and being overweight 3 years later

	Total			Boys			Girls		
Lifestyle factors	Non-overweight ($n=910$)	Overweight ($n=24$)	*P* value[a]	Non-overweight ($n=460$)	Overweight ($n=5$)	*P* value[a]	Non-overweight ($n=450$)	Overweight ($n=19$)	*P* value[a]
Eating quickly, *n* (%)									
Yes	109 (12.0)	6 (25.0)	0.105	80 (17.4)	2 (40.0)	0.215	29 (6.4)	4 (21.1)	0.037
No	801 (88.0)	18 (75.0)		380 (82.6)	3 (60.0)		421 (93.6)	15 (79.0)	
Exercise, *n* (%)									
Daily	433 (47.6)	5 (20.8)	0.002	280 (60.9)	1 (20.0)	0.069	153 (34.0)	4 (21.1)	0.072
Sometimes	281 (30.9)	7 (29.2)		111 (24.1)	2 (40.0)		170 (37.8)	5 (26.3)	
None	196 (21.5)	12 (50.0)		69 (15.0)	2 (40.0)		127 (28.2)	10 (52.6)	
Snack after dinner, *n* (%)									
Always or sometimes	467 (51.3)	15 (62.5)	0.279	256 (55.7)	4 (80.0)	0.390	211 (46.9)	11 (57.9)	0.347
Seldom or none	443 (48.7)	9 (37.5)		204 (44.4)	1 (20.0)		239 (53.1)	8 (42.1)	
Wake-up time, *n* (%)									
Before 6 : 30	327 (35.9)	10 (41.7)	0.677	162 (35.2)	2 (40.0)	1.000	165 (36.7)	8 (42.1)	0.723
6 : 30–6 : 59	263 (28.9)	5 (20.8)		130 (28.3)	1 (20.0)		133 (29.6)	4 (21.1)	
7 : 00 or later	320 (35.2)	9 (37.5)		168 (36.5)	2 (40.0)		152 (33.8)	7 (36.8)	
Bedtime, *n* (%)									
Before 21 : 00	35 (3.9)	1 (4.2)	0.432	10 (2.2)	0 (0.0)	1.000	25 (5.6)	1 (5.3)	0.337
21 : 00–21 : 59	499 (54.8)	10 (41.7)		259 (56.3)	3 (60.0)		240 (53.3)	7 (36.8)	
22 : 00 or later	376 (41.3)	13 (54.2)		191 (41.5)	2 (40.0)		185 (41.1)	11 (57.9)	
Sleep duration (hours), *n* (%)									
＜9.0	228 (25.1)	7 (29.2)	0.874	121 (26.3)	1 (20.0)	1.000	107 (23.8)	6 (31.6)	0.748
9.0–9.9	545 (59.9)	14 (58.3)		269 (58.5)	3 (60.0)		276 (61.3)	11 (57.9)	
10≤	137 (15.1)	3 (12.5)		70 (15.2)	1 (20.0)		67 (14.9)	2 (10.5)	

[a]Chi-square test or Fisher's exact test (Non-overweight vs. Overweight).

Table 4 Crude and adjusted RRs and their 95% CIs of eating quickly at baseline for being overweight 3 years later

	Total N	Overweight *n* (%)	Crude		Adjusted	
			RR (95% CI)	*P* value	RR (95% CI)	*P* value
Total ($n = 934$)						
Eating quickly						
Yes	115	6 (5.2)	2.37 (0.96–5.86)	0.061	3.65 (1.52–8.76)[a]	0.004
No	819	18 (2.2)	1.00		1.00	
Boys ($n = 465$)						
Eating quickly						
Yes	82	2 (2.4)	3.11 (0.53–18.34)	0.209	4.27 (0.76–24.07)[b]	0.100
No	383	3 (0.8)	1.00		1.00	
Girls ($n = 469$)						
Eating quickly						
Yes	33	4 (12.1)	3.52 (1.24–10.01)	0.018	3.69 (1.33–10.25)[b]	0.012
No	436	15 (3.4)	1.00		1.00	

RR, risk ratio; CI, confidence interval.
[a]Adjusted for sex, exercise, snack after dinner, and sleep duration at baseline.
[b]Adjusted for exercise, snack after dinner, and sleep duration at baseline.

One potential hypothesis to explain why eating quickly leads to overweight is that eating quickly leads to an increased total energy intake with overeating, resulting in overweight. Eating quickly was shown to be associated with a lack of satiety [17], as rapid eating may cause overeating before the stomach senses fullness [19]. In addition, a recent study showed that the eating rate was positively associated with energy intake [5]. However, another study showed that eating quickly was significantly associated with overweight/obesity even after adjustment for total energy intake [16], whereas the rate of eating was significantly positively associated with current BMI independent of energy intake [19]. A previous study showed that the effect of eating speed on overweight/obesity may be unrelated to that of total energy intake [15]. These studies suggest that our present findings were not substantially affected by energy intake. Because information regarding total energy intake was not obtained in our study, further studies including such information are needed to verify the present results.

In this study, the impact of eating quickly on overweight varied by sex; a significantly increased RR of eating quickly for being overweight was found in girls, whereas eating quickly did not significantly increase the RR for being overweight in boys. The results of this cohort study were not consistent with the findings of a cross-sectional study among adolescents [7]. The discrepancy might be due to the study design. In addition, a cross-sectional study revealed that a higher rate of eating was positively associated with an increased risk of overweight in children regardless of sex [5], which is not consistent with our findings. This discrepancy could also be due to the study design and to data collection. The information about the children's eating speed was collected from the parents in the previous study [5], whereas it was collected directly from the children in our study. Self-reported eating speeds might differ from parent-reported eating speeds and the difference could be larger in boys than in girls, resulting in the sex difference in the association between eating quickly and overweight in the present study. In our study, the proportion of children who became overweight during the 3-year period was significantly lower in the boys (1.1%) than in the girls (4.1%). A previous study showed that the incidence of obesity in a 6-year study period (from age 9 to age 15) was lower in boys than in girls [20], which is consistent with our present findings. Wells reported that sex differences in body composition are primarily attributable to the action of sex steroid hormones, which drive dimorphisms during pubertal development [21]. Therefore, sex hormones could lead to the sex difference in the incidence of being overweight during the period from preadolescence to adolescence. Because the biological mechanism of the sex difference in the relationship between eating quickly

and overweight is beyond the scope of the present study, our findings must be verified by future studies.

Another potential reason why the impact of eating quickly on overweight varied by sex might be the loss of statistical power. To improve the lack of statistical power, we additionally analyzed BMI as a continuous variable in a sub-analysis, in which we compared the change in BMI between fourth and seventh grade between the eating-quickly group and the not-eating-quickly group among 588 boys who were followed up and had no missing data. There was no significant difference between these two groups in the change in BMI; the partial regression coefficient of eating quickly was −0.051 (95%CI: −0.304 to 0.202). It will thus be necessary to examine the influence of sex differences on overweight due to eating quickly in future studies with larger sample sizes. For instance, if the required sample size is estimated based on the present study (boys who ate quickly: boys who did not eat quickly = 1 : 5, the risk among boys who ate quickly = 0.024 (2.4%), the risk among boys who did not eat quickly = 0.008 (0.8%), alpha = 0.05, and beta = 0.8), the required sample size is 2,934. It might be possible to examine the sex difference in a cohort study with a longer follow-up period.

The strength of this cohort study is that the follow-up rate was over 90%. Moreover, the height and weight of each subject at baseline and 3 years later were directly measured. However, there are some limitations in our study. First, information about eating quickly was self-reported, which might be not objective. However, Petty *et al.* reported that the self-reported eating rate aligned with laboratory-measured eating rate [22]. A recent study suggested that self-reports of eating quickly are related to a decreased number of chews until first swallow, the total number of chews, and the total duration of chewing, and that a self-reported questionnaire to evaluate the eating rate is valid in young people [23]. In addition, the repeatability (reliability) for self-reported eating quickly was shown; the kappa statistics for eating quickly were 0.63 in men and 0.67 in women [16]. Moreover, self-reported eating speed has been used for studies in several countries [7, 24-27]. Second, some potential confounders could have affected the present study results. For instance, information regarding irregular snacking, intakes of vegetables and fruits, socioeconomic status such as parental education and socioeconomic position—which have been reported to be associated with overweight/obesity among adolescents [28-31]—was not obtained. In addition, the height and weight of participants' parents were not measured in our study. Age in years and months might affect our study findings, because it may differ in our participants. The possibility of residual confounding is thus not denied. Third, eating volume was not adjusted for in this study; however, a previous study showed that the effect of eating speed on overweight/obesity may be unrelated to that of total energy intake [15], which suggested that our present findings were not substantially affected by eating volume. Fourth, a multilevel analysis might be more desirable in this study because the study data had a multilevel structure. Thus, a type 1 error may have occurred. Fifth, this study examined the relationship of eating quickly at baseline to overweight 3 years later, and thus the status of eating quickly at baseline might have changed during the 3-year follow-up, which could have affected our findings. Finally, the subjects were from one town in Japan, which might limit the generalizability to other populations.

In conclusion, our analyses demonstrated that eating quickly can lead to overweight in schoolgirls. Our findings suggested that the modification of eating quickly can help prevent overweight in adolescents.

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