Breastfeeding and Obesity Among Schoolchildren
A Nationwide Longitudinal Survey in Japan

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IMPORTANT
Although it is suggested that breastfeeding is protective against obesity in children, the evidence remains inconclusive because of possible residual confounding by socioeconomic status or children’s lifestyle factors. Most of the participants in the previous studies were children in Western developed countries, so studies in a different context are awaited.

OBJECTIVE
To examine the associations of breastfeeding with overweight and obesity among schoolchildren in Japan, with adjustment for the potential confounders.

DESIGN
Secondary data analyses of a nationwide longitudinal survey ongoing since 2001, with results collected from 2001 to 2009.

SETTING
All over Japan.

PARTICIPANTS
A total of 43,367 singleton children who were born after 37 gestational weeks and had information on their feeding during infancy.

EXPOSURES
Five mutually exclusive infant feeding practice categories.

MAIN OUTCOMES AND MEASURES
Underweight, normal weight (referent group), overweight, and obesity at 7 and 8 years of age defined by using international cutoff points of body mass index by sex and age.

RESULTS
In multinomial logistic regression models with adjustment for children’s factors (sex, television viewing time, and computer game playing time) and maternal factors (educational attainment, smoking status, and working status), exclusive breastfeeding at 6 to 7 months of age was associated with decreased risk of overweight and obesity compared with formula feeding. The adjusted odds ratios were 0.85 (95% CI, 0.69-1.05) and 0.55 (95% CI, 0.39-0.78) for overweight and obesity, respectively, at 7 years of age. Similar results were observed at 8 years of age.

CONCLUSIONS AND RELEVANCE
Breastfeeding is associated with decreased risk of overweight and obesity among schoolchildren in Japan. Therefore, it would be better to encourage breastfeeding even in developed countries.
Breastfeeding is considered one of the factors that may alleviate the epidemic of childhood obesity worldwide.1-5 Suggested mechanisms for the protective effect of breastfeeding against obesity are as follows. First, breastfed infants may have more discretion over the amount of milk they consume than those fed with infant formula, which could lead to better self-regulation of energy intake in later life.6,7 Second, breast milk contains hormones such as leptin, ghrelin, and adiponectin that may positively affect body fat deposition.4,8,9,10 Third, infant formula, by contrast, contains more protein than breast milk, which may result in increased adiposity and subsequent weight gain among formula-fed infants.7,11,12 Breastfeeding has, therefore, been highly recommended based on these possible protective effects as well as other positive effects in reducing infection or allergy-related outcomes.2

Several epidemiologic studies have shown a protective effect of breastfeeding on obesity among children. Indeed, meta-analyses have suggested a 15% to 20% reduced risk of obesity among breastfed children relative to formula-fed children.13,14 However, more recent studies cast doubt on the protective effect of breastfeeding. The major concern is that inadequate control for confounding factors (eg, socioeconomic status, dietary habit, physical activity, and maternal smoking) may explain the reported protective effect of breastfeeding.2,4,7 Because breastfeeding is considered to be driven by social context and most of the participants in the previous studies were children in Western developed countries, studies in a different context are awaited. Indeed, recent findings from Brazil and Hong Kong identified no association between breastfeeding and obesity,15-17 which further raised concerns about residual confounding in other studies. Moreover, a recent large-scale randomized trial did not support a protective effect of breastfeeding against obesity.18 These studies led to breastfeeding being considered “unlikely to be causally protective against childhood obesity” in a general medical journal.4 In the present study, we examined the association between breastfeeding and obesity among schoolchildren, with adjustment for important potential confounders using data from a large-scale nationwide database in Japan. Japanese children who were raised in a culture different from Western countries should aid in providing further insights into this association.

### Figure

**Figure. Flow Diagram for Selection of Participant Children From 2001 to 2009**

<table>
<thead>
<tr>
<th>53375 Babies born between January 10 and 17 or July 10 and 17 in 2001 in Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>47015 Questionnaires returned at the first survey</td>
</tr>
<tr>
<td>2906 Excluded</td>
</tr>
<tr>
<td>2418 Children born ≤37 gestational weeks</td>
</tr>
<tr>
<td>976 Twins or triplets</td>
</tr>
<tr>
<td>742 Feeding practice information missing</td>
</tr>
<tr>
<td>43367 Eligible children</td>
</tr>
<tr>
<td>9229 Lost to follow-up at the seventh survey</td>
</tr>
<tr>
<td>34138 Children at the seventh survey</td>
</tr>
<tr>
<td>4231 Children’s height and weight data missing at the seventh survey</td>
</tr>
<tr>
<td>837 Lost to follow-up at the eighth survey</td>
</tr>
<tr>
<td>33530 Children at the eighth survey</td>
</tr>
<tr>
<td>2750 Children’s height and weight data missing at the eighth survey</td>
</tr>
<tr>
<td>Children included in the analyses</td>
</tr>
<tr>
<td>29097 Aged 7 years (seventh survey)</td>
</tr>
<tr>
<td>30780 Aged 8 years (eighth survey)</td>
</tr>
</tbody>
</table>

### Methods

#### Study Participants

This study was approved by the institutional review board of Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences (approval 486). Since 2001, the Japanese Ministry of Health, Labour, and Welfare has been collecting information on family circumstances, child rearing, and children’s health and developmental status from families all over Japan in the Longitudinal Survey of Babies in the 21st Century.19 The primary goal of this survey is to study the growth of children and use this information to develop effective countermeasures to the declining fertility rate. The Ministry of Health, Labour, and Welfare mailed the first questionnaire to all families who had an infant between January 10 and 17 or July 10 and 17, 2001, when the infants were 6 months old. Among 53,575 questionnaires, 47,015 were returned (88% response rate), and follow-up questionnaires were sent every year. Currently, results from the first to ninth surveys (ie, 2001-2010) have been collected, and we obtained electronic data from the Ministry of Health, Labour, and Welfare without individual names and mailing addresses for the first 8 surveys. Birth records from Japanese vital statistics were also linked to the data from these surveys, such as gestational weeks, singleton birth or not, and sex.

In the present study, we targeted schoolchildren whose data were collected in the seventh and eighth surveys (ages 7 and 8 years, respectively). As shown in the Figure, we restricted the study participants to children born after 37 gestational weeks and those who were singleton births because of the potential influence of prematurity and multiples on children’s growth.20 This led to exclusion of 2418 and 976 children from each of the 2 surveys, respectively. Children with missing information on feeding practice during infancy (n = 742) were also excluded. At the seventh survey, 9229 children were lost to follow-up, and 4231 children with missing information on height or body weight...
were excluded, leaving 29,907 children in the analysis at 7 years of age. Similarly, at the eighth survey, 9837 children were lost to follow-up, and 2750 children with missing information on height or body weight were excluded, leaving 30,780 children in the analysis at 8 years of age.

Infant Feeding Practice

The initial survey at 6 months of age contained questions on infant feeding practice to determine whether children had been breastfed, only colostrum fed, or formula fed. The duration (in months) of breastfeeding and formula feeding was queried. In the present study, we combined “never breastfed” and “colostrum only” into a category of “formula feeding” because the number in the category of “never breastfed” was small and the duration of feeding colostrum is usually short (eg, approximately 1 week). We had categories of “partial breastfeeding” and “exclusive breastfeeding” using information on breastfeeding and formula feeding. We further divided the category of “partial breastfeeding” based on the duration of breastfeeding (ie, breastfeeding for 1-2 months, 3-5 months, and 6-7 months), following past studies.7,21 However, we do not have information about the timing and extent of breastfeeding in the category of “partial breastfeeding,” ie, we do not know when children had been breastfed or whether children had been exclusively or partially breastfed during the period of breastfeeding. Children in the category of “exclusively breastfeeding” had been breastfed for 6 to 7 months. Even though the initial survey was administered at 6 months of age, we had a category up to 7 months depending on the timing of the response. Finally, we categorized the feeding practice as follows: formula feeding, partial breastfeeding (ie, breastfeeding for 1-2 months, 3-5 months, and 6-7 months), and exclusive breastfeeding at 6 to 7 months of age.

Children’s Overweight and Obesity Status

We obtained children’s height and weight at 7 and 8 years of age, which were reported by parents in centimeters and kilograms, respectively, to 1 decimal point. We then calculated body mass index. Based on the age- and sex-specific body mass index cutoff points in children proposed by the International Obesity Task Force,22 we defined overweight and obesity by sex at 7 and 8 years of age, respectively. We also defined underweight based on the age- and sex-specific body mass index cutoff points following a previous international survey.23

Covariates

To adjust for residual confounding from socioeconomic status or children’s lifestyle, we included the following child and maternal characteristics that could affect the children’s lifestyle:24-26 children’s sex, television viewing time per weekday and computer game playing time per weekday, and maternal educational attainment, smoking status, and working status. Regarding the children’s factors, sex was listed in the birth record. Average television viewing time per weekday and average computer game playing time per weekday were obtained from the seventh and eighth surveys. Television viewing time, which included the original 8 categories, was organized into 5 as follows: less than 1, 1 to 2, 2 to 3, 3 to 4, and 4 or more hours. Computer game playing time, which included the original 8 categories, was also organized into 4 as follows: 0, less than 1, 1 to 2, and 2 or more hours. Regarding maternal factors, educational attainment was obtained from the second survey (when children were aged 18 months). We classified the original 8 categories into 4 as follows: junior high school and others, high school, junior college (2 years) or vocational school, and university (4 years) or higher. Smoking status was ascertained at the first survey. In the seventh survey, mother’s income earned from work was queried, so the mother earning income was assumed as having working status.

Statistical Analysis

To evaluate the impact of loss to follow-up and missing information on height or weight (Figure), we first compared baseline characteristics between eligible participant children in the initial survey and those remaining in the seventh and eighth surveys.

In multinomial logistic regression models, we estimated crude odds ratios (ORs) for the associations of infant feeding practice with underweight, overweight, and obesity against normal weight, using the category of “formula feeding” as a reference (model 1). Next, we adjusted for maternal factors (ie, educational attainment, smoking status, and working status) (model 2), then additionally adjusted for children’s factors (ie, sex, average television viewing time per weekday, and average computer game playing time per weekday) in the final model (model 3). Sex, smoking status, and working status were dichotomous. Television viewing time, computer game playing time, and educational attainment were categorical variables (as defined earlier) and were entered into the models as nominal variables.

In sensitivity analyses, we further adjusted for paternal annual income (as a continuous variable) plus the same set of covariates in model 3. Moreover, to mitigate the impact of residual confounding due to dietary habit, we additionally adjusted for families’ awareness about a healthy diet (ie, whether families were careful to reduce children’s sugar intake) as a dichotomous variable in model 3. This dietary habit marker was abstracted from the third survey.

All confidence intervals were calculated at the 95% level. Stata statistical software (Stata SE version 10; StataCorp) was used for all the analyses.

Results

Table 1 shows the baseline characteristics of eligible children, children included in the analyses at 7 years old, and those included at 8 years old. The proportion of exclusive breastfeeding at 6 to 7 months of age was more than 20%, while more than 70% had been partially breastfed and only 5% to 6% had been formula fed. Children included in the analyses at the ages of 7 and 8 years were more likely to have been breastfed and less likely to have mothers who smoked compared with all eligible children at baseline.

For children included in the analysis at 7 years of age, those whose mothers had higher academic attainment (ie, higher than junior college) and did not smoke were more likely to have been breastfed (data shown in eTable 1 in Supplement). In addition,
children who watched television and played computer games for fewer hours were more likely to have been breastfed. Children included in the analyses at 8 years of age showed the same tendencies (data shown in eTable 2 in Supplement).

At 7 years of age, 7.3% and 2.1% of the children were classified as overweight and obese, respectively (Table 2). The prevalence of both outcomes tended to decrease as the duration of breastfeeding increased. Breastfeeding was negatively associated with both outcomes in the crude model (model 1). Even after adjusting for the covariates, the protective associations for obesity remained significant in models 2 and 3. Indeed, in model 3, the OR was the lowest for the c...
The associations of infant feeding practice with overweight and obesity at age 8 years in 30,780 children are shown in Table 3. The table includes categories of feeding practice such as formula feeding, partial breastfeeding, and exclusive breastfeeding at 6 to 7 months of age, with corresponding odds ratios (OR) and 95% confidence intervals (CI) for overweight and obesity. For example, exclusive breastfeeding at 6 to 7 months of age was associated with an OR of 0.84 (95% CI, 0.70-1.00) for overweight and 0.56 (95% CI, 0.39-0.76) for obesity in model 3.

**Discussion**

We used a large nationwide data set (the Longitudinal Survey of Babies in the 21st Century) to examine the association of breastfeeding with overweight and obesity among schoolchildren in Japan, with adjustment for important potential confounders. The results showed that breastfeeding was associated with decreased risk of overweight and obesity at the ages of 7 and 8 years compared with formula feeding. Moreover, the protective associations for obesity were greater than those for overweight.

Major strengths of the present study are that the number of participants is large compared with previous studies and the participants are considered to be representative of Japanese children. The present finding among schoolchildren in Japan, therefore, provides further evidence on the protective effect of breastfeeding. A previous study conducted in a similar Asian country, Hong Kong, did not find a protective effect of breastfeeding. However, the proportion of exclusive breastfeeding was quite high in the present data set (>20%) compared with the study in Hong Kong (<7%), probably because Japanese society has promoted breastfeeding, which might explain the different findings between these countries.

Because of concern about residual confounding from socioeconomic status or children's lifestyle factors, the protective effect of breastfeeding on obesity has been suggested as unlikely to be causal. However, in the present study, even after adjusting for these important potential confounders, ex-
exclusive breastfeeding at 6 to 7 months of age relative to formula feeding was associated with a 15% decreased risk of overweight. Moreover, the association was stronger for obesity, ie, a 45% decreased risk. These findings are consistent with the previous meta-analyses, mostly including white children, that indicated that breastfeeding was associated with a 15% to 20% decreased risk of obesity relative to infant formula.13,14

Although the protective associations of breastfeeding for overweight and obesity were observed both at 7 and 8 years of age, the associations for obesity were stronger at 8 years of age than those at 7 years of age. This may be explained by statistical chance or different sample sizes between the analyses at ages 7 and 8 years.

An important limitation of the present study is the loss of participants from the initial survey to the seventh and eighth surveys. As shown in Table 1, children included in the analyses at ages 7 and 8 years were more likely to have been breastfed and less likely to have mothers who smoked, compared with all eligible children in the first survey. Considering that children whose mothers are smokers are more likely to be more obese,21 we could argue that obese children who had been formula fed were more likely to be lost to follow-up. Such a differential loss would underestimate the protective effect of breastfeeding, ie, moving ORs to null.

The duration of breastfeeding should be accurate because the information on feeding practice was collected at the first survey (ie, when children were aged 6-7 months). However, the following limitations related to the information on breastfeeding need to be addressed in future studies. First, we could not evaluate the effect of both partial and exclusive breastfeeding beyond 6 to 7 months of age. Next, we could not obtain information on the mode of breast milk delivery (ie, directly or by bottle), which might be related to weight gain.27 We also could not ascertain whether children were given any liquids (eg, water and sugar solution) at the hospital or home during the first half-year of infancy from the questionnaire; thus, the category of “exclusive breastfeeding” may include predominantly breastfed children.28

The measurement of height and weight should also be accurate. A past study suggested that children’s anthropometric measurement reported by parents is valid even when collected by self-administered questionnaires.29 In addition, regular checkup of children’s height and weight at school are required by law in Japan, and parents are informed of the results.

Because we could not adjust for maternal obesity, which is related to children’s lifestyle according to the previous studies,6,7,30 we instead adjusted for maternal characteristics (smoking status and working status). However, we cannot exclude the possibility of residual confounding due to maternal obesity even after the adjustments. Moreover, although we additionally adjusted for the single item of families’ dietary awareness in the sensitivity analysis, the residual confounding due to families’ dietary awareness may still remain.

Finally, there is a concern about other residual confounding by genetic traits. For example, children who grow rapidly and need more energy intake may be given infant formula in addition to breast milk. However, this concern could not explain the present finding because the reduced risk was also observed among children who had been exclusively breastfed at 6 to 7 months of age relative to those who had been formula fed. The availability of information on both feeding practices (ie, breastfeeding and infant formula) in the present study could exclude such a possibility.

In conclusion, after adjusting for potential confounders, we demonstrated that breastfeeding is associated with decreased risk of overweight and obesity among schoolchildren in Japan, and the protective association is stronger for obesity than overweight.

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JAMA Pediatrics  October 2013  Volume 167, Number 10

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