The school lunch law was enacted in 1954 in Japan (1). In 2009, 99.2% of elementary schools had school lunch programs (full meals: 98.1%, supplementary meal (offering main dish and/or side dish and milk, without staple food): 0.5%, milk only: 0.6%) (2). The Ministry of Education, Culture, Sports, Science and Technology (MEXT) establishes guidelines for making school lunches (3). Nutritional standards for energy, protein, total fat, salt (sodium), calcium, iron, magnesium, vitamin A, vitamin B1, vitamin B2, vitamin C and dietary fiber are given according to 4 age groups (6–7 y, 8–9 y, 10–11 y and 12–14 y) without gender difference. One of the features of the Japanese guidelines for making school lunches is special consideration for calcium and vitamin B1. The nutritional standard for calcium is set to 50% of the tentative dietary goal for preventing lifestyle related diseases (DG) because of the difficulty of obtaining it in the Japanese daily diet (Japanese guidelines for making school lunches refer to Dietary Reference Intakes 2005 (DRIs 2005) (4). DG was set for calcium in DRIs 2005.) Vitamin B1 is set to 40% of recommended dietary allowance (RDA) because it is easy to become deficient.

The purpose of this study was to estimate the usual intake distribution of calcium and vitamin B1 of fifth-grade children based on a 3-d dietary survey and to assess nutrient intake using Dietary Reference Intakes (DRIs 2010). A cross-sectional study was undertaken from October 2007 to February 2008 in schools located in Tokyo and Okayama, Japan. A total of 94 fifth-grade children attending 5 elementary schools participated in the study. The weighed plate waste method and observation were used to collect data on the school lunches and dietary records by children, accompanied by photographs used to collect data on meals at home. The study lasted 3 d, 2 non-consecutive days with school lunches and 1 d without. The estimated proportion of subjects below the Estimated Average Requirement (EAR) for calcium intake with milk in the school lunch decreased by 40% compared to the calcium intake without milk in the school lunch. Vitamin B1 intake from less than 0.45 mg/1,000 kcal fortified rice was estimated to be 0%. The intake distribution of calcium has increased by 150 mg by taking milk and the intake distribution of vitamin B1 has increased 0.20 mg by taking fortified rice in the school lunch. Calcium and vitamin B1 intake in the school lunch has changed the distribution of calcium and vitamin B1 intake upward, and decreased the number of estimated subjects that were below EAR. However, the distribution was not shifted across the board and the shape of the distribution has changed.

Key Words school lunch, children, dietary assessment, Dietary Reference Intakes

How Does Fortification Affect the Distribution of Calcium and Vitamin B1 Intake at the School Lunch for Fifth-Grade Children?

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(Received June 13, 2012)

Summary The purpose of this study was to estimate the usual intake distribution of calcium and vitamin B1 of fifth-grade children based on a 3-d dietary survey and to assess nutrient intake using Dietary Reference Intakes (DRIs 2010). A cross-sectional study was undertaken from October 2007 to February 2008 in schools located in Tokyo and Okayama, Japan. A total of 94 fifth-grade children attending 5 elementary schools participated in the study. The weighed plate waste method and observation were used to collect data on the school lunches and dietary records by children, accompanied by photographs used to collect data on meals at home. The study lasted 3 d, 2 non-consecutive days with school lunches and 1 d without. The estimated proportion of subjects below the Estimated Average Requirement (EAR) for calcium intake with milk in the school lunch decreased by 40% compared to the calcium intake without milk in the school lunch. Vitamin B1 intake from less than 0.45 mg/1,000 kcal fortified rice was estimated to be 0%. The intake distribution of calcium has increased by 150 mg by taking milk and the intake distribution of vitamin B1 has increased 0.20 mg by taking fortified rice in the school lunch. Calcium and vitamin B1 intake in the school lunch has changed the distribution of calcium and vitamin B1 intake upward, and decreased the number of estimated subjects that were below EAR. However, the distribution was not shifted across the board and the shape of the distribution has changed.

Key Words school lunch, children, dietary assessment, Dietary Reference Intakes

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fortified rice, which are special considerations in the Japanese guidelines for making school lunch menus, were studied and we discussed the role of school lunch for children in Japan.

**MATERIALS AND METHODS**

*Participants and study design.* A cross-sectional study was undertaken from October 2007 to February 2008. The convenience sample recruited was comprised of 317 fifth-grade children aged 10 to 11 y at 2 elementary schools in Tokyo and 3 elementary schools in Okayama, Japan. Each school had 1 or 2 classes in fifth-grade, and 11 to 40 children were in each class. Out of 107 children who participated in the study, 12 did not offer complete data for analysis and 1 was without anthropometric measurement; thus, 94 children were included for analysis. The study lasted 3 d, 2 non-consecutive days with school lunches (weekdays) and 1 d without (Saturday or Sunday).

*Collecting data on the school lunches.* We conducted the weighed plate waste method and observation to collect data on the school lunches. All plates were weighed before and after eating, using electronic scales (No. 1157, Tanita Corporation, Japan). Trained research staff (approximately 10 children per researcher) observed the children while they were eating and noted the estimated portion weight and which children were involved in food trades.

The weighed plate waste method was implemented as follows. After foods were served to children, research staff weighed each plate. If foods were served again (second helpings), plates were weighed again. Once children finished eating, they left the classrooms or lunchrooms, leaving the tray and tableware on the table with their number tags given before eating. Then research staff took pictures of the plates with number tags and weighed the plates. Pictures were used for confirming data.

The school lunches of the elementary schools in Tokyo were prepared on the schools’ own premises, while school lunches at the 3 elementary schools in Okayama were prepared at a centrally located school lunch service center. School lunch menus were made following guidelines from MEXT (12) and 1 elementary school in Tokyo made school lunches following guidelines from MEXT (13), which in turn followed guidelines from MEXT (12). Children ate their school lunches either in classrooms or lunchrooms, depending on the school. In all the schools, school lunch was served by the children themselves.

*Collecting data on meals at home.* Dietary records by children accompanied by photographs were used to collect data on meals at home. We gave to each child a disposable camera, a lunch mat which had a ribbon to indicate the distance to take pictures, 3 recording papers, and a brochure of how to take pictures.

The dietary record was implemented as follows. Children put meals on the lunch mat before eating and took pictures, then wrote down the name of dishes and ingredients, and amounts or portion size on the record-
RESULTS

Table 1 summarizes the characteristics of the subjects. The estimated proportion of the subjects below EAR for the usual intake of calcium with and without milk, and the usual intake of vitamin B₁ with and without fortified rice in school lunches is shown in Table 2. The estimated proportion of the subjects below EAR for usual intake of calcium with milk in the school lunch was 25.5%. The estimated proportion of the subjects below EAR for usual intake of calcium without milk in school lunches was 67.0%. Therefore, the intake distribution of calcium has been shifted upward by providing milk in school lunches (Fig. 1). No children were estimated to be at risk for vitamin B₁ deficiency for the usual intake of vitamin B₁ with fortified rice. The estimated proportion of subjects below EAR for the usual intake of vitamin B₁ without fortified rice in school lunches was 34.2% for boys, and 57.1% for girls. Vitamin B₁ intake of less than 0.45 mg/1,000 kcal with fortified rice was estimated to be 0% and 24.5% for vitamin B₁ intake without fortified rice. The intake distribution of vitamin B₁ has been shifted upward by providing fortified rice in school lunches (Fig. 2). The intake distribution of calcium has been shifted 150 mg upward by providing milk (50th percentile of calcium with milk: 700 mg, 50th percentile of calcium without milk: 551 mg) and the intake distribution of vitamin B₁ has been shifted 0.20 mg upward by providing fortified rice in school lunches (50th percentile of vitamin B₁ with fortified rice: 1.10 mg, 50th percentile of vitamin B₁ without

Table 1. Characteristics of subjects.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Boys n=38</th>
<th>Girls n=56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending school</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Elementary school A</td>
<td>28 (73.7)</td>
<td>43 (76.8)</td>
</tr>
<tr>
<td>Elementary school B</td>
<td>3 (7.9)</td>
<td>4 (7.1)</td>
</tr>
<tr>
<td>Elementary school C, D, E¹</td>
<td>7 (18.4)</td>
<td>9 (16.1)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>Anthropometric measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>141.7±5.2</td>
<td>140.4±5.0</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>35.7±8.7</td>
<td>33.9±6.4</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>17.7±3.7</td>
<td>17.1±2.5</td>
</tr>
<tr>
<td>Energy intake (kcal)</td>
<td>2,160±196</td>
<td>1,896±150</td>
</tr>
</tbody>
</table>

¹ School lunches at the 3 elementary schools were prepared at a centrally located school lunch service center.

Fig. 1. Distribution of usual intake of calcium with and without milk in school lunches.

Fig. 2. Distribution of usual intake of vitamin B₁ with and without fortified rice in school lunches.
Distribution of calcium intake of milk, vitamin B1 of fortified rice and rice intake in school lunches is shown in Fig. 3. Additionally, descriptive statistics are shown in the figure. The amount offered for calcium from milk was 227 mg. The median for calcium from milk was also 227 mg and 95.2% of subjects consumed whole milk (it was not shown in the figure). The amount offered was 0.30 mg and the median was 0.25 mg for vitamin B1 from fortified rice. CV was 9.7% for calcium from milk, 31.8% for vitamin B1 from fortified rice and 30.1% for rice. The distribution of the amount of calcium from milk consumed in school lunches is concentrated in one place and distribution of the amount of vitamin B1 consumed from fortified rice and rice in school lunches is widespread.

**DISCUSSION**

**Distribution change of calcium**

In the present study, we estimated the usual intake distribution of calcium with and without milk. The amount offered for calcium from milk was 227 mg. The median for calcium from milk was also 227 mg. The intake distribution of calcium has been shifted 150 mg upward by providing milk in school lunches and the shape of the distribution was almost unchanged. In this study, more than 90.0% of subjects consumed all the milk; therefore CV of calcium from milk was 9.7%. Calcium from milk which is mostly bottled or packaged is not influenced by the amount served and influenced only by second helpings and plate waste.

The estimated proportion of the subjects below EAR for calcium intake with milk in school lunches decreased 40% from calcium intake without milk in school lunches. Hodges et al. pointed out that increased accumulation of calcium occurred with an increase in calcium intake (18). Therefore it is important to decrease the estimated proportion of the subjects below EAR for calcium for children in the developmental stage.

**Distribution change of vitamin B1**

We estimated the usual intake distribution of vitamin B1 with and without fortified rice in school lunches. The intake distribution of vitamin B1 has been shifted 0.20 mg upward by providing fortified rice in school lunches. The amount offered was 0.30 mg, and the median was 0.25 mg for vitamin B1 from fortified rice. Therefore, this study showed that when intake distribution shifted, 0.30 mg of vitamin B1 (the amount offered) was not shifted across the board and the shape of the distribution changed because the amount of rice consumed was different for each child. In this study, CV of vitamin B1 from fortified rice was 31.8%. One of the explanations for this is that vitamin B1 from fortified rice is influenced by second helpings, plate waste and amount served. In addition, distribution of the amount of rice consumed was widespread (Fig. 3). Considering the vitamin B1 functions as a coenzyme in the metabolism of carbohydrates and branched-chain amino acids (18), it could be thought to be effective to add vitamin B1 to staple foods such as rice that contribute to energy. The estimated proportion of the subjects below EAR for vitamin B1 intake with fortified rice in school lunches showed that no children were at risk for vitamin B1 deficiency. In addition, vitamin B1 intake of less than 0.45 mg/1,000 kcal with fortified rice was estimated to be 0%. Vitamin B1 has active urinary excretion and functions as a coenzyme in the metabolism of carbohydrates and branched-chain amino acids (19); therefore to assess vitamin B1 intake, it is desirable to use these two methodologies, such as the estimated proportion of the subjects below EAR and vitamin B1 intake per energy intake.

**The roles of school lunch for children**

In this study, we assessed how the distribution of calcium and vitamin B1 intake changed for fifth-grade children with school lunches, using dietary data, not the amount offered in school lunch menu. The result of this study showed that calcium and vitamin B1 intake in

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**Table 2. Estimated proportion of subjects below estimated average requirement and percentile distribution for usual intake of calcium with and without milk and usual intake of vitamin B1 with and without fortified rice in school lunches.**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>At risk level</th>
<th>% of population at risk&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Mean</th>
<th>SD</th>
<th>Intake distribution percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5th</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25.5</td>
</tr>
<tr>
<td>With milk in school lunch</td>
<td>&lt;600 mg</td>
<td>67.0</td>
<td>568</td>
<td>175</td>
<td>320</td>
</tr>
<tr>
<td>Without milk in school lunch</td>
<td>&lt;600 mg</td>
<td>25.5</td>
<td>717</td>
<td>156</td>
<td>486</td>
</tr>
<tr>
<td>Vitamin B1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>With fortified rice in school lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Boys</td>
<td>&lt;1.0 mg</td>
<td>34.2</td>
<td>1.04</td>
<td>0.12</td>
<td>0.83</td>
</tr>
<tr>
<td>Girls</td>
<td>&lt;0.9 mg</td>
<td>57.1</td>
<td>0.90</td>
<td>0.11</td>
<td>0.73</td>
</tr>
<tr>
<td>Without fortified rice in school lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Boys</td>
<td>&lt;1.0 mg</td>
<td>24.5</td>
<td>0.95</td>
<td>0.13</td>
<td>0.76</td>
</tr>
<tr>
<td>Girls</td>
<td>&lt;0.9 mg</td>
<td>24.5</td>
<td>0.95</td>
<td>0.13</td>
<td>0.76</td>
</tr>
</tbody>
</table>

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<sup>1</sup> Percentage below estimated average requirement.
school lunches changed the distribution of calcium and vitamin B1 intake upward and decreased the number of the estimated proportion of subjects below EAR. Milk is the principle product to provide calcium, but milk has been provided in school lunches because of policy implications of food production, not only public health nutrition (20). Therefore we considered it’s important to clarify the nutritional aspects of milk in school lunches. The results of this study supports the concept of guidelines for making school lunches, such as taking foods which contain high target nutrients or using fortified food in school lunches where children consume the same food. This approach leads to changes in the distribution shift of whole groups (3). However, the result of vitamin B1 of this study showed that when intake distribution shifted, the shape of the distribution did not maintain its original shape. Therefore, it could be understood that in planning a diet for groups if there are individual differences in the amount served and amount consumed, the intake of fortified nutrients and target nutrients in food would also be influenced by the amount served and amount consumed. From the point of view of planning diet, the goal is to decrease the numbers of persons below EAR and to have none above Tolerable Upper Intake Level (UL) (3). Consequently, to change the distribution shift of groups through school lunches, firstly, it is necessary to assess the dietary intake at both school and home and also health conditions. Then, it becomes
possible to consider the shift of intake distribution by which foods and by how much.

This study has some limitations. Previous dietary surveys of the Japanese population pointed out that there is a seasonal difference in nutrient intake (10, 21, 22). We used 3 d of dietary survey data from October to March for estimating the usual intake. However seasonal differences in nutrient intake could not be considered sufficiently. The other limitation is that the number of study participants was limited. In this study, consent for only the school lunch survey and questionnaire were obtained from 235 children and 107 children for both school lunch and meals at home. During weekdays, of the children who participated in the dietary survey at home, nobody answered that they had skipped breakfast. On the other hand, of the children who did not participate in the dietary survey at home, 11 children answered that they skip breakfast 1 or 2 d per week. During weekends, of the children who participated in the dietary survey at home, 6 children answered that they skip lunch sometimes and 15 children who did not participate in the dietary survey at home. There was no difference between height and weight among the two groups of children. Considering these revelations, the dietary intake for children who participated in the dietary survey at home and children who did not was inferred to be different. Therefore, the percentage of estimated usual intake below EAR in this study is probably lower than the actual value.

The generalizations of our findings may be limited. This study was conducted in 5 elementary schools and used a total of 6 menus and the amounts consumed were analyzed. Participants from elementary school A were bigger than other elementary schools; therefore, the results obtained from this study were possibly influenced by participants from elementary school A. We conducted the survey on the day of offering rice as the staple food. If we conduct the survey on the day of offering bread or noodles as the staple food, the results may be different for fortification of those products. According to the report of MEXT, rice as a staple food has been offered in 99.9% of schools which have implemented full meals and the frequency is 3.2 times a week (2). In this study, 2 schools offered rice 3 times a week and 1 school offered rice 2 times a week. Therefore, it cannot be said that schools which conducted the survey are exceptional.

It is recommended for future studies which assess dietary intake of some districts, to consider sample size and methodology to choose participants that minimizes the influence of the numbers of participants and menus.

Acknowledgments

The authors express their thanks to the school teachers and parents of the participants. Above all, the authors wish to express their deepest appreciation to the study participants themselves for their cooperation throughout the study. This study was funded by the Sasakawa Scientific Research Grant from the Japan Scientific Society. No potential conflict of interest was reported by the authors.

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