Effects of the National School Lunch Program on Bone Growth in Japanese Elementary School Children

Toshiyuki KOHRI¹, Naoko KABA¹, Tatsuki ITOH¹ and Satoshi SASAKI²

¹Department of Food and Nutrition, Faculty of Agriculture, Kindai University, Nara 631–8505, Japan
²Department of Social and Preventive Epidemiology, School of Public Health, The University of Tokyo, Tokyo 113–0033, Japan

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Summary The Japanese school lunch program with milk was designed to supply 33–50% of the necessary nutrients per day and 50% of the recommended dietary allowance for calcium, which is difficult to obtain from Japanese meals. Although this program contributes to the mental and physical development of children, the effect of these meals on the bone growth in children remains unknown. Therefore, we compared the effect of school lunch with milk on bone growth between elementary school children attending schools that did not enforce the school lunch with milk program (box-lunch group) and those attending schools that did enforce the program (school-lunch group). The study subjects included fourth-grade children during the 2009–2013 school years, of whom 329 children were in the school-lunch group and 484 children in the box-lunch group. The bone area ratio of the right calcaneus was evaluated using quantitative ultrasound (Benus III). Dietary intakes were assessed using brief self-administered diet history questionnaires. The subjects were asked to record their activities for 3 d so that the mean physical activity intensity and the time spent sleeping could be estimated. The bone area ratios (%) were significantly higher in the school-lunch group than in the box-lunch group (males 31.0 ± 0.3 vs. 30.3 ± 0.2; females 30.6 ± 0.2 vs. 29.7 ± 0.2). This tendency did not change even after adjustment for confounding factors associated with bone growth. The results suggest that nutrients supplied by the Japanese school lunch program contributed to increased bone growth in elementary school children.

Key Words bone growth, bone mineral density, school children, school lunch, box lunch

It is essential for school-aged children, who experience remarkable mental and physical development, to obtain nutrients necessary for healthy growth. One of the services that are important in providing adequate nutrients to Japanese children is school-provided lunch. The School Lunch Program Law was enacted in 1954 in Japan, and since then, school lunch has been provided as a part of the education system throughout Japan (1). According to the survey on the current status of school lunches conducted in 2013 (2), 98.4% of Japanese elementary schools enforce the school lunch program with milk, suggesting that almost all elementary schools in Japan enforce this program. The school lunches were designed according to the guidelines for making school lunches established by the Ministry of Education, Culture, Sports, Science and Technology (3). The standard values for the intake of energy, protein, lipids, salt, calcium, iron, vitamin A, vitamin B₁, vitamin B₂, vitamin C, and dietary fiber as well as the reference values for magnesium and zinc intake have also been determined in this guideline. The standard values for school lunches were designed to provide 1/3 of the energy/nutrients necessary per day for children. For calcium and magnesium, in which Japanese people tend to be deficient, 50% of the recommended dietary allowance and for vitamin B₁, vitamin B₂, 40% of the recommended dietary allowance is provided by school lunches. Some reports have indicated that this school lunch program has contributed to the improvement in the status of nutrient intake in elementary school children. Nozue et al. suggested that calcium and vitamin B₁ intake was greater in fifth-grade students on days when they were provided with school lunches than on days when they were not and that the percentage of students whose nutrient intake was below the estimated average requirement (EAR) was smaller for students who received school lunches (4). Thus, the school lunch program has contributed to health promotion and improved physical strength in children through the improvement in nutrient intake and is expected to establish appropriate dietary habits in children through dietary education based on school lunch as a theme (1). However, there are no reports on the effects of school lunch on bone growth in children. In developed countries, such as Japan, the number of osteoporosis patients has been increasing along with the average life span. Therefore, prevention of osteoporosis is now a very important issue. It is estimated that a 10% increase in peak bone mass could delay the development of osteoporosis by 13 y (5) and decrease the risk of osteoporotic fractures after menopause by 50% (6).
Thus, maximizing the peak bone mass is the preferred approach for preventing fractures in later years. Therefore, examining the effects of the Japanese school lunch program on bone growth in children who have not yet achieved their peak bone mass would be useful. In addition, there is also a concern that dietary surveys are not as accurate in children as in adults for investigating the relationship between diet and bone growth (7). Therefore, the objective of this study was to investigate the effects of school lunch with milk on bone growth by comparing children who continuously ate school lunches with those who ate box lunches brought from home, without relying on dietary surveys.

SUBJECTS AND METHODS

Subjects. The purpose of this study was explained, during the 2009–2013 school years, to 558 children in the fourth grade of a private elementary school in the Kinki region who had been bringing lunchboxes from home (box-lunch group) and to 416 children in the fourth grade of a public elementary school who had been provided with school lunch with milk (school-lunch group). Table 1 shows the average nutritional value of the school lunch with milk provided at school (3). Informed consent for study participation was obtained from every participant and from their parent or guardian in accordance with the Declaration of Helsinki. This study was conducted with the approval of the Kindai University Faculty of Agriculture Life Ethics Committee. A total of 489 private and 340 public elementary school children participated in this study. We excluded 16 subjects who reported extremely low or high energy intake (i.e., <0.5 times the estimated energy requirement value for the lowest physical activity category or >1.5 times that for the highest physical activity category, according to the dietary reference intakes for Japanese issued in 2015). The exclusion criteria used in the study of Murakami et al. (8) were applied in the present study.

The analysis set finally included 484 children (262 males and 222 females) in the box-lunch group and 329 children (153 males and 176 females) in the school-lunch group. Each survey was conducted between May and July of each year.

Anthropometric measurement. Data for body weight (kg) to the nearest 0.1 kg and standing height (cm) to the nearest 0.1 cm while the children were wearing light clothes were obtained from the most recent anthropometric measurement records at the subjects’ schools.

Bone measurement. Bone measurement was performed following the method reported by Kohri et al. (9). In brief, the bone status of the right calcaneus was evaluated using quantitative ultrasound densitometry (Benus III; Ishikawa Seisakusho, Ltd., Japan). The definition of “bone growth” in this study was the bone status of the calcaneus evaluated by the Benus III, and the bone area ratio (BAR) was used as an evaluation index. BAR refers to the percentage of the area that bone trabeculae (osslein) occupy in the sectional area and correlates ($r=0.83$, $p<0.01$) with bone mineral density by dual-energy X-ray absorptiometry measurement of the calcaneus (10, 11). The coefficient of variation of the densitometer has been reported to be 0.8% for speed of sound and 1.6% for BAR of the calcaneus (10).

Assessment of nutrient and food groups intake and general questionnaire. The survey on the status of nutrient and food groups intake and the questionnaire survey were conducted following the method reported by Kohri et al. (9). In brief, nutrient and food groups intake were assessed using a brief self-administered diet history questionnaire modified for elementary school children (BDHQ-10y) (12) to assess the habitual diets of elementary school children aged 9–10 y.

The BDHQ-10y was distributed to the children with a request for the parents or guardians to help the children provide the answers. The participants completed the questionnaires with the help of their parent/guardian at home and returned them to their classroom teachers. A general questionnaire was also distributed, which the participants had to answer at school.

Assessment of mean physical activity intensity per day. The assessment of the mean physical activity intensity per day was performed following the method reported by Kohri et al. (9). In brief, the participants were asked to record all of their activities at home for 3 d (2 weekdays and 1 holiday) with the help of their parent/guardian so that we could estimate their mean physical activity intensity per day. The physical activity intensity of each day was evaluated as the metabolic equivalent (MET) intensity according to the physical activity level codes (13). The mean physical activity intensity level for a single day was estimated using the following equation:

Mean physical activity intensity level for a single day (METs) = $\sum$[Intensity of each activity (METs) × Time of each activity (min)] ÷ 1,440 (min)

The mean physical activity intensity level per day was then estimated using the following equation:

Mean physical activity intensity level per day (METs) = [Mean METs on a weekday

Table 1. The standard mean nutritional values supplied in a school lunch meal.

| Age (y)   | 6–7 | 8–9 | 10–11 |
|----------|-----|-----|-------|
| Energy (kcal) | 530 | 640 | 750 |
| Protein (g)   | 20  | 24  | 28   |
| Fat (percent energy) | 25–30 | 25–30 | 25–30 |
| Salt (g)      | <2  | <2.5| <2.5 |
| Calcium (mg)  | 300 | 350 | 400 |
| Iron (mg)     | 2   | 3   | 4    |
| Vitamin A (µg RAE) | 150 | 170 | 200 |
| Vitamin B1 (mg) | 0.3 | 0.4 | 0.5 |
| Vitamin B2 (mg) | 0.4 | 0.4 | 0.5 |
| Vitamin C (mg) | 20  | 20  | 25   |
| Dietary fiber (g) | 4   | 5   | 6    |
| Magnesium (mg) | 70  | 80  | 110 |
| Zinc (mg)     | 2   | 2   | 3    |
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**Table 2. Basic characteristics of the subjects in the box-lunch and school-lunch groups.**

|                      | Males                          |  | Females                     |  |
|----------------------|--------------------------------|---|-----------------------------|---|
|                      | Box-lunch (n = 262)            |  | School-lunch (n = 153)      |  |
|                      |                                |  |                            |  |
| Age (y)              | 9.2 ± 0.4                      |  | 9.3 ± 0.4                   |  |
| Height (cm)          | 134.9 ± 5.9                    |  | 134.7 ± 5.8                 |  |
| Weight (kg)          | 31.7 ± 7.0                     |  | 30.2 ± 5.6*                 |  |
| BMI (kg/m^2)         | 17.3 ± 2.8                     |  | 16.6 ± 2.3**                |  |
| Mean PA intensity (MET)^1 | 1.81 ± 0.25                    |  | 1.90 ± 0.29**               |  |
| Sleeping time (min)  | 533.0 ± 86.8                   |  | 548.6 ± 43.5*               |  |
| Length of time since menarche (mo) | — | — | 527.8 ± 50.8        | 0 |

BMI: body mass index; Mean PA intensity: mean physical activity intensity per day.

1 Mean PA intensity (MET) was estimated from activity records for 3 d.

* p<0.05, ** p<0.01, *** p<0.001: Box-lunch vs. School-lunch (t-test).

**Table 3. Estimated intake of major nutrients per day assessed via brief self-administered diet history questionnaires.**

| Nutrient     | Males                          |  | Females                     |  |
|--------------|--------------------------------|---|-----------------------------|---|
|              | Box-lunch (n = 262)            |  | School-lunch (n = 153)      |  |
|              |                                |  |                            |  |
| Energy (kcal) | 1,898.8 ± 377.3                |  | 2,002.8 ± 421.9*           |  |
| Protein (g)  | 70.1 ± 15.5                    |  | 70.9 ± 16.3                |  |
| Fat (percent energy) | 28.3 ± 4.2                     |  | 30.5 ± 3.8***              |  |
| Salt (g)     | 10.3 ± 2.2                     |  | 10.0 ± 2.4                 |  |
| Calcium (mg) | 577.9 ± 160.8                  |  | 728.2 ± 174.7***           |  |
| Iron (mg)    | 8.0 ± 1.7                      |  | 7.7 ± 2.0                  |  |
| Vitamin A (µg RAE) | 711.9 ± 251.6                 |  | 730.5 ± 250.0              |  |
| Vitamin B1 (mg) | 0.86 ± 0.19                   |  | 0.88 ± 0.21                |  |
| Vitamin B2 (mg) | 1.45 ± 0.31                   |  | 1.62 ± 0.35***             |  |
| Vitamin C (mg) | 158.0 ± 50.7                   |  | 140.4 ± 51.7**             |  |
| Dietary fiber (g) | 12.4 ± 3.1                    |  | 11.9 ± 3.7                 |  |
| Magnesium (mg) | 238.8 ± 52.1                   |  | 242.6 ± 59.4               |  |
| Zinc (mg)    | 8.5 ± 1.7                      |  | 8.6 ± 2.0                  |  |

* p<0.05, ** p<0.01, *** p<0.001: Box-lunch vs. School-lunch (t-test).

a p<0.05. a*p<0.01, a**p<0.001: Males vs. Females in the box-lunch group (t-test).

b p<0.05, bbb p<0.001: Males vs. Females in the school-lunch group (t-test).

**RESULTS**

For the children in the box-lunch and school-lunch groups, the means and standard deviations of the age, height, weight, BMI, mean physical activity intensity factors that were believed to affect bone growth, including body mass index (BMI), mean physical activity intensity per day, and time spent sleeping, between the two groups. The amount of nutrient intake was evaluated by calculating the percentage of children whose nutrient intake was below the EAR or that of children whose nutrient intake was beyond the range of the dietary goal (DG) in the dietary reference intakes for Japanese issued in 2015. The differences in these percentages between the box-lunch and school-lunch groups were evaluated using the chi-square test.

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Statistical analysis. All statistical analyses were performed using SPSS version 18.0 for Windows and were separately performed for each sex. The data for females were not separated by menarche status because menarche had not occurred in the female subjects. All descriptive results were expressed as means and standard deviations, except for BARs, which were expressed as means and standard errors. Except for the BARs, Student’s t-test was used to evaluate differences in the mean value of each data set between the box-lunch and school-lunch groups. One-way analysis of variance was used to evaluate the differences in the mean values of BARs, and one-way analysis of covariance was used to evaluate the differences in the mean values adjusted for.
Table 4. Percentage of subjects below EAR or out of appropriate range of DG for nutrients.

| Nutrient                    | Box-lunch n=262 | School-lunch n=153 | Males | Females | Box-lunch n=222 | School-lunch n=176 |
|-----------------------------|------------------|--------------------|-------|---------|-----------------|--------------------|
| Protein                     | 0.4              | 0.0                |       |         | 0.0             | 1.1                |
| Fat (percent energy)        | 34.0             | 56.2***            |       |         | 36.5            | 58.0***            |
| Salt                        | 99.2             | 98.7               |       |         | 95.9            | 93.2               |
| Calcium                     | 46.6             | 15.7***            |       |         | 71.6            | 47.7***            |
| Iron                        | 14.1             | 22.9*              |       |         | 24.3            | 39.8***            |
| Vitamin A                   | 1.9              | 2.6                |       |         | 4.5             | 4.0                |
| Vitamin B1                  | 45.8             | 48.4               |       |         | 60.8            | 69.9               |
| Vitamin B2                  | 3.1              | 1.3                |       |         | 12.6            | 6.8                |
| Vitamin C                   | 0.0              | 0.0                |       |         | 0.9             | 0.6                |
| Dietary fiber               | 5.11             | 61.4               |       |         | 58.1            | 79.5***            |
| Magnesium                   | 3.1              | 2.0                |       |         | 6.8             | 10.8               |
| Zinc                        | 1.1              | 1.3                |       |         | 4.5             | 6.3                |

EAR, estimated average requirement; DG, tentative dietary goal for preventing life-style-related diseases.
* p<0.01, ** p<0.001; Box-lunch vs. School-lunch (Chi-square test).

Table 5. Estimated intake of food groups per day assessed via brief self-administered diet history questionnaires and calcium supply rate derived from each food group.

| Food groups (g) | Box-lunch n=262 | School-lunch n=153 | Males | Females | Box-lunch n=222 | School-lunch n=176 |
|-----------------|------------------|--------------------|-------|---------|-----------------|--------------------|
| Grain           | 434.0±133.5 (5.4)| 395.2±115.8** (4.4)|       |         | 390.6±139.2** (5.8)| 352.5±129.9*** (4.4)|
| Potato          | 58.2±22.1 (1.0)  | 55.7±23.9 (0.8)    |       |         | 53.9±20.2* (1.1) | 45.9±19.3*** (0.8)  |
| Sugar & sweetener| 3.3±1.6 (0.0)   | 3.1±1.6 (0.0)      |       |         | 3.3±1.7 (0.0)    | 2.9±1.6* (0.0)      |
| Bean            | 51.1±27.3 (7.6)  | 51.6±27.6 (6.2)    |       |         | 43.6±24.1* (7.5) | 42.6±27.5* (6.1)    |
| Vegetable       | 281.6±108.5 (18.6)| 250.2±91.9** (12.9)|       |         | 259.7±95.1* (20.3)| 236.9±90.3* (15.0)  |
| Fruit           | 170.6±131.0 (3.2)| 121.1±112.7* (1.6) |       |         | 157.2±131.6 (3.5)| 135.8±122.5 (2.1)   |
| Seafood         | 68.8±30.6 (12.0) | 53.0±23.4*** (8.1) |       |         | 62.1±31.5* (13.0)| 49.5±27.5*** (8.2)  |
| Meat            | 79.4±32.1 (0.7)  | 76.2±31.6 (0.5)    |       |         | 68.2±21.0*** (0.7)| 61.2±19.0*** (0.5)   |
| Egg             | 40.0±17.8 (3.5)  | 36.9±18.3 (2.6)    |       |         | 36.3±15.1* (3.7) | 29.7±16.9*** (2.5)  |
| Milk            | 208.6±104.3 (40.5)| 360.6±104.2*** (56.1)|       |         | 158.3±83.1*** (35.7)| 285.5±110.9*** (52.7)|
| Oil & fat        | 12.5±4.8 (0.0)   | 12.5±4.3 (0.0)     |       |         | 11.0±3.6** (0.0)| 10.7±3.5*** (0.0)   |
| Confectionery    | 32.1±24.6 (2.3)  | 48.7±31.8*** (2.7) |       |         | 34.3±23.8 (3.0)  | 45.4±30.3*** (3.1)  |
| Beverage        | 572.3±215.6 (2.8)| 657.3±268.7*** (2.5)|       |         | 565.7±204.5 (3.1)| 608.0±231.9 (2.8)   |
| Seasoning & spice| 247.8±140.0 (2.3)| 226.6±108.0 (1.7)  |       |         | 231.4±114.9 (2.5)| 210.5±113.5 (1.8)   |

The value in parentheses indicates the calcium supply rate (%) derived from each food group.
* p<0.05, ** p<0.01, *** p<0.001; Box-lunch vs. School-lunch (t-test).
* p<0.05, ** p<0.01, *** p<0.001; Males vs. box-lunch group (t-test).
* p<0.05, ** p<0.01, *** p<0.001; Males vs. Females in the box-lunch group (t-test).

per day, time spent sleeping, and time (mo) since the first menstruation are presented in Table 2. No differences in age or height for males or females were observed between the groups. For male children, weight and BMI were significantly higher in the box-lunch group than in the school-lunch group, and the mean physical activity intensity per day and the time spent sleeping were significantly greater in the school-lunch group than in the box-lunch group. For female children, the time spent sleeping was significantly longer in the school-lunch group than in the box-lunch group. In the box-lunch group, the weight, BMI, and mean and physical activity intensity per day were significantly higher for male children than for female children, and in the school-lunch group, the mean physical activity intensity per day was significantly higher for male children than for female children. No female children had started menstruation. For children in the two groups, the means and standard deviations of energy and the amount of major nutrient intake are presented in Table 3. For male children, energy, calcium, and vitamin B2 intake as well as the fat energy ratio were greater and vitamin C intake was smaller in
the school-lunch group than in the box-lunch group. For female children, calcium and vitamin B₂ intake was higher in the school-lunch group than in the box-lunch group. For female children, milk and confectionery intakes were lower in the school-lunch group than in the box-lunch group. In both groups, milk intake and the majority of food groups intakes were higher in males than in females. In addition, the calcium supply rate derived from milk was the highest in the food groups.

The means and standard errors of BARs before and after adjustment in the box-lunch group and the school-lunch group are presented in Fig. 1. Before adjustment, BAR values were significantly higher in the school-lunch group than in the box-lunch group for both males and females. Even after adjusting for BMI, mean physical activity intensity per day, and time spent sleeping, which were believed to affect bone growth, BARs were significantly higher in the school-lunch group than in the box-lunch group for both males and females.

**DISCUSSION**

Although >50% of the variance in peak bone mass is attributable to genetic factors (14), there are manageable environmental factors that can modify bone growth, such as nutritional intake (15, 16). The primary objective of this study was to evaluate the effects of meals, particularly the school-provided lunch with milk, on bone growth in children. For this purpose, the measurement of BARs and comparisons of BARs between the school-lunch and box-lunch groups were performed considering the factors that could affect bone growth in children, such as BMI, mean physical activity intensity per day (9), and time spent sleeping (17). It is also known that sex hormones remarkably affect bone growth in children (9, 18). Therefore, in this study, we selected fourth-grade students in whom secondary sex characteristics were not yet prominent (19) and for whom the duration of exposure to school lunch was probably the longest. The results of the survey revealed that no female child had started menstruation. It is known that secondary sex characteristics appear later in males than in females (19). Hence, in this study, there should have been only a minor effect of sex hormones on bone growth in the subjects. Consequently, the nutrition provided by the box lunch and school lunch may have had a greater effect on bone growth than sex hormones and have led to the differences between the two groups. There are many reports on the relationship between the amount of dietary nutrient intake and bone mineral density (20, 21); however, the results are not necessarily consistent with each other. This inconsistency may partly be due to errors in dietary surveys (22). It has been reported that such errors in dietary surveys are greater in children than in adults (23). In this study, to assess the effects of school-provided lunch with milk on their bone growth, the subjects were divided into two groups: 1) elementary school children participating in the school lunch with milk program and 2) elementary school children not participating in the school lunch program and who ate lunches brought from home. The results showed that BAR values were higher in the children who had been eating school
lunches than in the children who had been eating lunches brought from home for both males and females, even after adjusting for factors that could affect bone growth, such as BMI, mean physical activity intensity per day, and time spent sleeping (9, 17). Except for school holidays, school lunch was provided to the children for approximately half of the total number of days throughout the year. Moreover, the subjects were fourth-grade children who had been eating their meals, either school lunches or lunches brought from home, for those days at least for the past 3 y. The type of lunches eaten over the 3-y period might explain the differences in BARs between these groups. The significance of this study is that the results suggest that eating school-provided lunches with milk is more beneficial than eating lunches brought from home with respect to bone growth. Our results did not use dietary surveys, the accuracy of which may be unreliable for children. In this study, habitual diet was also assessed with parents’ help using the BDHQ-10y, for which limited validity is guaranteed if parents help fill out the questionnaire (12). Regarding the amount of calcium intake, which may be deficient in Japanese, the percentage of children with calcium deficiency was remarkably lower in the school-lunch group than in the box-lunch group in both sexes, although it had been assumed that approximately 50% of males and 70% of females in the box-lunch group would show deficiency. The school lunch provided at schools included 200 mL of milk, which contained approximately 220 mg of calcium. The total amount of milk intake in the school-lunch group was significantly higher than that in box-lunch group for both sexes. The supply rate of calcium derived from milk was the highest in the food groups. Furthermore, Uenishi et al. reported that the absorption rate of calcium from milk was the highest (39.8%) in the food groups (24); it appeared to be obvious that the milk contributed greatly to the improvement in calcium deficiency. According to the systematic review and meta-analysis by Tai et al. (21) on the relationship between the amount of calcium intake and bone mineral density, even if calcium intake from dietary sources increased, the risk of fracture would not clinically decrease because the increase in bone mineral density would be subtle. However, the subjects of these studies were older adults (aged > 50 y); the effects of increased calcium intake on bone mineralization may be different among older adults, whose bone mass has been decreasing, and children, whose bone mass has been increasing. Uenishi and Nakamura suggested a positive dose-effect relationship between milk intake and bone strength in Japanese high-school students (25). Furthermore, it has been reported that only subjects with low daily calcium intake can benefit from increased calcium intake (26). In this study, daily calcium intake in the box-lunch group, which was between 500 and 600 mg for both sexes, was relatively low. Therefore, the results suggest that calcium, which was supplemented in the school lunches, was beneficial for bone growth. For another nutrient, vitamin B2, which serves as a cofactor or substrate of the enzymes involved in homocysteine metabolism, 40% of the recommended dietary allowance is provided by school lunches. In this study, the vitamin B2 intake was significantly higher in the school-lunch group than that in the box-lunch group for both sexes. Yazdanpanah et al. concluded that increased dietary vitamin B2 intake was associated with higher femoral neck bone mineral density (27). Therefore, the vitamin B2 supplemented in the school lunches may help in bone growth. Our study had some limitations. First, direct comparisons of nutrient contents between the box lunch and the school lunch were not performed because the nutrients in the lunchboxes brought from home were unknown. However, we have previously assessed the surface area ratio of staple : main : side items in lunchboxes by taking images with a digital camera of each lunchbox brought by fifth-grade students attending the same elementary school, as in this study for the box-lunch group, and reported that the majority of the surface area was occupied by staple foods, such as rice, and some main foods, including meat. The area for side items, such as vegetables, was smaller, and there were hardly any dairy products (28). At least, calcium content in the box lunch seemed lower than that in the school lunch. Second, the amount of leftover food for the school lunch and the box lunch was unknown. For school lunch, Kojima et al. (29) investigated the status of leftover food in fifth- and sixth-grade children. They reported that 36.7% of the children did not finish their meals, and their amount of nutrient intake was 20–30% lower than that in the children who finished their meals. In addition, Nozue et al. (30) reported that 95.2% of fifth-grade students had consumed 200 mL of milk without any left over, although there were some individual differences in terms of quantity of served food for main and side items. In contrast, it has been reported that the amount of leftover food (unconsumed) in the box-lunch group was low because parents/guardians knew how much and what kind of food their children would eat (28). In that study, it appeared necessary to know the food intake status at lunchtime, including the amount of leftovers, to clarify the effects of school lunch on bone growth. Regarding other limitations, for males, differences were observed in the weight, BMI, physical activity intensity, and the time spent sleeping between the two groups. The reason may be because of differences among school curriculums. However, there was no difference in the weight, BMI, or physical activity strength for females. A further study is necessary to determine these relationships.

The present study showed that the school lunch with milk program may contribute to bone growth in elementary school children, without relying on dietary surveys, the accuracy of which is difficult to control, particularly in children. The average life span of populations has increased in many advanced countries, including Japan; therefore, controlling the increase in the number of osteoporosis patients has become an important social issue. Hence, we believe that the results of this study in Japan may be applicable to other populations.
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