Survey of a Japanese Elementary School Lunch Program Menu Planning, Quality Control, and Nutrition Management: A Case Study

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ABSTRACT

Objective: School lunch programs maintain and enhance the nutritional status of schoolchildren and assist in the healthy development of the children. The aims of this study were to observe and assess how quality control and nutrition and meal management systems are operated in a Japanese elementary school lunch program and to reveal current practices.

Methods: A key informant interview with the diet and nutrition teacher in charge of the school lunch program was conducted to assess the food service management system at A Elementary School, a public school in Saitama Prefecture. Details of current practices in preparing and serving school lunches, data on intake status, and information on the physical conditions of the schoolchildren were collected from three types of records (a scheduled school lunch menu, a stockpot quantity chart, and a plate waste log) for the months of April and September 2015 and January 2016. The energy targets, energy intake, and 33% of the estimated energy requirements (EERs) were then compared.

Results: The energy targets for school lunches was calculated by using the values for grades 3 and 4 as a reference and was revised three times per year (April 2015, September 2015, and January 2016) to account for the growth of the children. These target values for the service standard of energy, which were determined 2 months before the commencement of the school lunch program, exceeded the representative value; in other words, 33% of the EER at the time of serving the meals. The food service management system used the energy targets for grades 3 and 4 as the reference for planning menus and used conversion factors (80% for grades 1 and 2, 100% for grades 3 and 4, and 120% for grades 5 and 6) to determine adequate serving portions. Regarding school lunch consumption levels, although some plate waste was observed among children in grades 1 and 2, none was seen in grades 3 to 6. The energy intake of school lunches exceeded 33% of EER, and the values increased as the grades got higher. The observed values also increased over the 3 recorded months.

Conclusion: In the food service management system of A Elementary School, the energy targets for school lunches was set higher than 33% of EER. Although some food waste was seen in grades 1 and 2, none was seen in grades 3 to 6. Proper quality control was practiced in the school lunch program, which indicated that proper nutrition and meal management of schoolchildren was being conducted.

Key words: Japanese elementary school lunch, nutrition and meal management, food service management, quality control of school lunch

I. Introduction

The School Lunch Act1) ensures that school lunch programs assist in the healthy mental and physical development of schoolchildren as part of the education system, and it is tasked with nurturing a better dietary understanding and teaching children how to make sound food-related choices. School lunch meals are provided to pupils during lunchtime on school days. As school lunch meals are served on a regular basis, meal plans need to reflect the nutritional status of the schoolchildren and to consider nutrition and meal management for growth. To develop desirable dietary habits, meal plans also need to consider seasonal food choices, food combinations, and appropriate

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food portions and tastes and to include aspects of traditional culinary culture by serving festival meals and local dishes.

Pursuant to the Health Promotion Act\(^2\), the nutritional management of school lunch programs, which provide large quantities of meals on a continuous basis, is required by law. Standards for nutritional management stipulate the need to conduct regular assessments of the users of school lunch programs to determine their physical condition, nutritional status, and lifestyle-related disease status. Based on these assessments, programs need to provide meals with adequate quantities of calories and nutrients, implement quality control procedures, and conduct assessments\(^3\).

Quality control is indispensable from the operational side of producing and serving school lunches that maintain and improve the nutritional status of schoolchildren. Ideally, an operation that prepares meals for a large number of pupils needs to prepare food in large quantities efficiently, and from a quality control perspective, school lunch programs need to evaluate and improve menu planning and actual food preparation through the plan-do-check-act (PDCA) cycle\(^4\). The quality of a school lunch is determined by ensuring the provision of not only adequate energy and nutrients for schoolchildren, but also proper portions, taste, colors (visual appeal), textures, temperatures, and sanitary safety.

Consequently, current school lunch programs are required to conduct nutritional assessments (such as physical condition, nutritional status, and lifestyle habits) of schoolchildren regularly and to ensure the quality of school lunches through the PDCA cycle.

Various studies have reported on the nutritional management of school lunches. Kitade et al.\(^5\) determined school lunch reference intake for separate school lunch production facilities, Kojima et al.\(^6, 7\) assessed the nutritional intake and physical size of grade 5 and 6 pupils through school lunch leftovers, and Nozue et al.\(^8\) studied the relationship between food consumption and body weight in children. There have also been school lunch quality control studies that have investigated the nutritional content of school lunch meals\(^9\) and reported on quality control inspection systems from the perspective of hygiene management\(^10\).

These studies aimed to gain an understanding of the current status (nutritional assessment) and intake of children; however, although they investigated the nutrient content of school meals, they did not perceive school meal programs as a chain of events in the food service management system, linking children’s nutritional status with quality control (nutrient content). No studies have been conducted to assess and monitor schoolchildren in school lunch programs that have determined the service standards of nutrient targets for school lunch meals and applied those standards to the food service management of school lunch programs.

Therefore, this study assessed from a quality control perspective menu planning, production, and provision practices in the food service management system of an elementary school to determine whether the energy content of school lunches was appropriate for pupils’ growth. The findings were compared with the estimated energy requirements (EERs) calculated based on anthropometric measurements according to the Dietary Reference Intake for Japanese\(^11\), which serve as a nutritional assessment, to reveal the current practices of nutrition and meal management in the food service management system. The present study assessed nutrition and meal management using energy content based on the standard energy intake of a meal\(^12\).

II. Methods

The present study assessed the school lunch program at a public elementary school in City A in Saitama Prefecture, located within 30 km from the capital city of Tokyo. In total, 427 pupils (88 in grade 1, 66 in grade 2, 82 in grade 3, 71 in grade 4, 54 in grade 5, and 66 in grade 6) in the participating school were surveyed during April of the surveyed school year. Because of pupils transferring in and out of school that year, there were 423 pupils in January. The male to female ratio was almost the same, at 51.1% boys and 48.9% girls. This public elementary school had 16 classes and met the appropriate school size guidelines\(^13\) (12~18 classes) set by the Ministry of Education, Culture, Sports, Science, and Technology. The implementation rate of school lunch programs was 99.1% at national, public, and private elementary schools in Japan for the 2015 school year, and the implementation rate of the full school lunch program (staple food, accompanying dishes,
and milk) was 98.5%\(^{14}\). The surveyed elementary school was offering the full school lunch program.

Approval for this study was obtained from the research ethics committee of Jumonji University (2016-033).

1. Survey method and period

A survey was conducted using the interview method. A key informant interview with the diet and nutrition teacher, who was in charge of the school lunch program and provided dietary guidance at the elementary school, was conducted in March 2017. Details of the current practices used for preparing and serving school lunches at the public elementary school, data on intake status, and information on the physical condition of the schoolchildren were collected during the survey periods of April and September 2015 and January 2016. The survey period coincided with the pupils’ health checkups to collect pertinent nutritional assessment information.

2. Details of the survey

1) Procedures used in the food service management system

Using standard school lunch flowcharts\(^{15}\), the diet and nutrition teacher responsible for the school lunch program was asked about the procedures used in food service management for providing school lunches. The questions focused on two perspectives: nutritional management of the pupils and quality control of the school lunches. Standard flowcharts used in food service management assessed\(^{15}\), in order, nutritional status of the users, nutrition and meal management, menu controls, production management, provision and purchasing management, understanding of food intake status and amounts, and nutritional status assessments.

2) Quality control of school lunches

The following number of school lunches were provided during the survey period: 15 in April 2015 (13 for grade 1 pupils), 19 in September 2015 (17 for grade 6 pupils), and 14 in January 2016 (13 for grade 6 pupils). As part of quality control, information on serving sizes and nutrient amounts provided in the school lunches were collected from the following three documents during the survey months: scheduled school lunch menu, stockpot quantity chart, and plate waste log.

The scheduled school lunch menu for each month records the date, day of the week, menu item (dish), main ingredients of the dish, energy content for grades 3 and 4, and protein content. The dates, names of the menu items, and energy content were obtained from this document.

The stockpot quantity chart lists the serving size by dish for each grade. The list shows the quantity of food (in kg) by grade for each date, day of the week, and menu item (dish). This document was used to obtain the food quantities for each date, menu item, grade, and dish. The serving size of each meal on a particular school lunch day was obtained by dividing the weight of each dish for each grade by the total number of pupils in each grade. After calculating the serving size per person (for each dish), the total amount of food on the menu for each grade was summed. As milk was served to all pupils in individually packaged 200 ml cartons, this volume was converted to weight (206 g) and added to the tally.

\[
\text{Serving size per meal} = (\text{total weight of all dishes for each grade}/\text{total number of pupils in each grade}) + \text{weight of milk (206 g)}
\]

The plate waste log lists the amount of plate waste (in kg) by class for each date, day of the week, and menu item (dish). The unit for milk was 200 ml (206 g), and the leftover amounts were recorded. These values were used to determine the intake amount per person (for each dish). First, the plate waste quantity for each dish in each grade was subtracted from the quantity of the dish for each grade listed on the stockpot quantity chart. This value was then divided by the total number of pupils in the grade. Lastly, the intake amount for each of the dishes was tallied. The amount of leftover milk was subtracted from the served amount (206 g), and, similar to the other dishes, the converted weight was added to the intake amount per person.

\[
\text{Intake amount per person} = (\text{weight of a dish for each grade} - \text{amount of plate waste of a dish for each grade})/\text{total number of pupils in each grade} + (206 \text{ g of milk} - \text{amount of leftover milk per person})/206 \text{ g}
\]

Energy intake per person was calculated for each grade using the following formula, which was based on the serving size per meal of grades 3 and 4, listed as energy content per meal on the scheduled school lunch menu plus the energy content of milk per person (138 kcal):

\[
\text{Energy intake per person} = (\text{energy content of a meal for grades 3 and 4} - 138 \text{ kcal}) \times (\text{intake amount per person in each grade/average serving size per person in grades 3 and 4}) + 138 \text{ kcal} \times (206 \text{ g of milk} - \text{amount of leftover milk per person})/206 \text{ g}
\]
3) Service standard of energy target for school lunches and EERs

The planned energy target for the 2015 school year was obtained from the diet and nutrition teacher during the key informant interview.

The 33% EERs (EER33% hereafter) were obtained based on anthropometric data (date of birth, sex, height, and body weight) measured during the health checkups in April and September 2015 and January 2016. The median value was established as the standard intake of energy of a school lunch meal at A Elementary School. To determine the EER, the pupils’ physical activity levels were calculated in reference to the corresponding physical activity levels of schoolchildren established by MEXT in the Criteria for Provision of School Lunches (partial amendment)\(^{15}\); 1.55 for grades 1 and 2 (ages 6 and 7); 1.60 for grades 3 and 4 (ages 8 and 9); and 1.65 for grades 5 and 6 (ages 10 and 11). The EER for a school lunch meal was calculated as 33% of one day’s requirement established by the partial revision of Criteria for Provision of School Lunches\(^ {16}\).

3. Data and statistical analysis

The following data, shown as mean values by grade and month, were used to assess the quality control of school lunch meals: serving size of each meal, amount of intake per person, and energy intake per person. Kondate-Meijin nutrient analysis software (Integrated System Technology Co., Ltd., Osaka, Japan) was used to calculate the energy served in the planned meals.

The EER of the pupils was determined using the Nutritional Guidance and Support Program for Children version 1, developed by The Japan Dietetic Association’s School Health and Education Division (2012).

Data analysis was conducted using Microsoft Excel 2010 (Japan Microsoft Corporation, Tokyo, Japan) in SPSS version 21 (IBM Inc., Tokyo, Japan). Statistical analysis for serving size and amount of intake were conducted using a two-way analysis of variance so that comparisons by grade and month were not repeated. All of the reported \(p\) values were two-sided and considered statistically significant at the 0.05 level.

III. Results

1. Procedures used in the food service management system

Figure 1 is a flow chart showing the procedures used in the nutrition and meal management and food service management at A Elementary School. The school lunch program for the 2015-2016 school year began in April 2015; however, the nutritional planning process for the school lunch program began 2 months earlier.

1) Nutritional assessment and establishing the amounts of nutrients to be served

The service standard of nutrients targets for the 2015-2016 school year was established in February 2015 using the nutritional standards of school lunches\(^ {16}\) and the local government’s service standard of nutrient targets and incorporating data from previous plate waste surveys. The service standard of energy targets proposed by the local government was 640 kcal for grades 3 and 4. Using this value as a reference point, A Elementary School set the April figures to be 3% lower, the September figures to be the same, and the January figures to be 3% higher than the local government’s proposed figures. The energy targets for school lunches was set three times per year to accommodate the children’s growth. In other words, the energy targets for school lunches was 620 kcal in April, 640 kcal in September, and 660 kcal in January. As part of the dietary guidance, an annual teaching plan was created outlining the school lunch meals for a year starting in April.

2) Nutrition and meal management

The school lunch meal was a full school meal program providing pupils with a set meal complete with a staple food, accompanying dishes, and milk. A staple food was served at every meal, five times per week. The types of staple foods offered were rice, bread, and noodles served in a 3:1:1 ratio, respectively. The accompanying dish category consisted of main dishes, side dishes, soups, and desserts. The menus were planned so that each meal included a primary dish combined with another item from the accompanying dish category, in other words, a combination of two dishes or more from the accompanying dish category.

3) Food service management

Regarding quality planning, the cooking method of the
primary dish was deep frying twice a week, and a roux-based dish was served once a week. The children’s guardians pay for the school lunches at an ingredient cost of 237 JPY per meal. The school lunch program also catered and planned for children with food allergies.

4) Menu controls

Menus (including festive menus) were planned based on the energy targets for school lunches and prepared for the entire month, 2 months in advance. Menus were based on the annual teaching plan proposed in the dietary guidance. Local produce was introduced, and the menus were designed to make meals relevant to teaching points of particular food items. The menus avoided redundancy creatively by changing cooking methods and types of staple foods. Rice, bread, and noodles were served in a 3:1:1 ratio per week.

Figure 1  Flowchart of the procedures used in the present study

| Nutritional assessment | Evaluation of needs of target (group/individual) |
|------------------------|--------------------------------------------------|
| Basic data: sex, age (6-12 years), height, weight, body mass index, degree of obesity and growth curve, etc. |

| School lunch nutrition planning |
|--------------------------------|
| School lunch nutritional standards of our elementary school |
| Determination of service standard of nutrients |

| Nutrition and meal management |
|-------------------------------|
| Meal pattern: Full school meal program |
| Number of meals: 510 (16 classes) |
| Mealtime: 12:30 to 13:15 |
| Number of servings: 195/year |
| Eating environment: by group in each classroom |

| Food service management |
|-------------------------|
| Quality control of school lunch |
| (Design quality of school lunch) |
| Independent kitchen system |
| Complete meal: staple food, accompanying dishes (main dish, side dishes, soup, dessert), and milk |
| Types of staple foods: rice, bread, and noodles in a 3:1:1 ratio per week |
| Cooking style: fried twice, roux once/week |
| Standardized school lunch fee at an ingredient cost of 237 JPY per meal |

| Menus (menu planning) |
|-----------------------|
| Aim for a food that can be a teaching material. Based on the annual dietary guidance plan, prepare a menu for 1 month. |
| Include local products and events and tailored cooking instructions |
| Confirmation of the number of meals (whether there is an event or absence) → preparation of cooking instructions |
| Individual response plan for children with food allergies (instructions on removal, substitute food or bringing in meals) |

| Dietary Guidance |
|------------------|
| Confirmation of lesson plans based on developmental stage |
| Preparation of food lesson plans |
| Preparation of teaching materials |
| Create bulletin in line with school lunch target |
| Support children’s activities (daytime broadcast manuscript) |
| Distribution of menu and food education news |
| Confirmation for pupils with food allergies (parents, homeroom teachers, managers, nurses) |

| Material management |
|---------------------|
| Confirm quote for foods and ingredients (confirmation of standards etc.) |
| Confirmation and estimation of cultivation situation of local farmers |
| Check stock and ordering work (weight of ingredients for dish (g) × number of pupils = ordering quantity) |

| Production management |
|-----------------------|
| Confirm cooking process with chef |
| Confirm and order the necessary number of cooking pots |
| Order for each store (about 25) → Complete the instructions |
| Confirm allergen removal and alternative meals |
| Confirm work schedule table (prepared by chef) |
| Acceptance, cooking, meal delivery, and clean-up |
| Hygiene management (check based on HACCP) |

| Understanding of eating (ingestion) status |
|------------------------------------------|
| Eating situation (how to eat, ease of eating) |
| Weight of school lunch, weight of plate waste, actual intake |
| Whether it is safe to arrange and clean up |
| Whether allergic children eat a meal and do not have symptoms |

| Assessment of nutritional status | Child/parent’s level of satisfaction |
|---------------------------------|-----------------------------------|
| Assessment of eating habits and behaviors |
| Demands of parents |

| Quantity assessment |
|---------------------|
| Productivity assessment |
| Financial evaluation |
| Employee satisfaction |
ple foods on a daily basis. The menus were created with care to avoid overlapping the use of food ingredients, seasonal foods, cooking methods, and seasonings while incorporating the children’s preferences. The diet and nutrition teacher and cooking supervisor evaluated the planned menus to check whether the combination of dishes was feasible from the perspective of cooking time and equipment availability. Subsequently, preparation and cooking recipes were created for each day of the school lunch program and passed on to production management.

Energy and nutrient content of the food items on the menu was calculated, and a menu with all the main food items was printed and distributed to the schoolchildren. For children with food allergies, along with the menu, a separate customized support document was attached. As a reference, the menus had the portion sizes for grades 3 and 4.

5) Material management

The quantity of food ingredients to be purchased was calculated by adding the amount noted on the menu with the amount of waste material such as the skins and cores of vegetables and fruits. The amounts for grades 3 and 4 on the menu were used to determine the amounts of the other grade groups, using a factor of 80% for grades 1 and 2 and a factor of 120% for grades 5 and 6. The respective figures for each of the grade groups were then multiplied by the number of pupils. The specifications for each food item, quantity (weight), day of use, and date of delivery were indicated on the purchase order and sent to the supplier. All food items for the school lunches were delivered on the day of use for hygiene management purposes.

6) Production and provision management

All the food preparation staff involved in the production of the school lunches had a thorough pre-preparation meeting with the diet and nutrition teacher. At the meeting, the operation schedule for the preparation and the workload for each cooking staff were reviewed. To provide sufficient amounts of food to the children, prepared weight of food per kettle was shown.

The prepared food was transferred into stockpots and delivered to the classrooms. Each stockpot was filled with the correct amount of food, which was calculated based on the number of pupils in the classroom. The same factors used to calculate the purchasing quantities of food ingredients (80% for grades 1 and 2, 100% for grades 3 and 4, and 120% for grades 5 and 6) were used to determine the amount of finished product per person (using grades 3 and 4 amounts as the reference). This amount was multiplied by the number of pupils in the class to determine the total amount to be served per class. The stockpots were filled with the appropriate amount of food while double-checking the amount. As milk was already individually packaged, milk cartons were delivered according to the number of pupils in each class.

After the lunches were delivered to each classroom in stockpots, the pupil servers dished out each dish according to the predetermined serving portions. As a sample, the actual portion size per meal was on display in front of the school kitchen.

7) Dietary guidance

Relevant information based on the dietary guidance was shared in the classroom and in the lunchroom. As this paper focuses on food service management issues, some details have been omitted.

8) Assessment of consumption

A total of 510 meals (for pupils and teachers) were served. The lunch period was approximately 45 minutes, between 12:30 and 13:15, and the time allocation was as follows: 15 minutes to prepare, 25 minutes to eat, and 5 minutes to clean up. Everyone started eating together after saying the traditional Japanese utterance before a meal, *itadakimasu,* and ended the meal with the after-meal utterance of *gochisousama.* During cleanup after mealtime was over, any leftovers were returned to each of the original stockpots so that no food was left on individual plates. The food that was left inside the stockpots was measured and recorded as the plate waste. School meal intake was calculated by subtracting the plate waste from the served amount per person. Through observation of daily meal consumption, the eating patterns and preferences of the pupils were noted. A preference survey was also conducted once a year.

2. Portion size of the served meals (per person)

Table 1 shows the weight of served meals (production quality) per person in accordance with the menu planning process (quality planning). The amount of food served by weight was as follows: 501 to 535 g for grade 1, 500 to 533 g for grade 2, 573 to 615 g for grade 3, 576 to 619 g for grade 4, 654 to 701 g for grade 5, and 658 to 702 g for grade 6. The weight of the served staple food and accom-
accompanying dishes was separated into three groups: i) grades 1 and 2, ii) grades 3 and 4, and iii) grades 5 and 6. All grades received the same milk carton weighing 206 g per carton. However, foods that could not be divided into 1 g units, such as sausages (15 g per sausage), were separated into two groups: i) grades 1, 2, and 3 (one sausage) and ii) grades 4, 5 and 6 (two sausages). The served amounts by grade and month were analyzed using a two-way analysis of variance of meal intake (staple food, accompanying dishes, and milk).

### Table 1  Portion sizes of the served meals by grade and month

| Month* | Year (age in years) | 1st (6) | 2nd (7) | 3rd (8) | 4th (9) | 5th (10) | 6th (11) |
|--------|-----------------|--------|--------|--------|--------|----------|----------|
| April 2015 | 15 (1st: 13) | 524 ± 38 | 519 ± 37 | 597 ± 46 | 601 ± 47 | 679 ± 56 | 681 ± 56 |
| September 2015 | 19 (6th: 17) | 501 ± 47 | 500 ± 48 | 573 ± 60 | 576 ± 60 | 654 ± 72 | 658 ± 74 |
| January 2016 | 14 (6th: 13) | 535 ± 48 | 533 ± 48 | 615 ± 60 | 619 ± 60 | 701 ± 72 | 702 ± 75 |

Values are expressed as mean ± standard deviation.

The portion size of the served meal was calculated by adding i) the amount of food per person, which was obtained by dividing the amount of food served to each grade by the total number of pupils, and ii) the amount of milk (206 g) in each individual carton.

*Number of school lunches

The numbers inside the brackets show the grade and the number of served meals that were different.

Grade and month effects were analyzed by two-way analysis of variance to avoid repetition.

Grade effect: *p = 0.00;* month effect: *p = 0.00.*

### Figure 2  Mean of intake amount and energy

Milk intake = served milk (206 g) – leftover milk (g)/total number of pupils in the grade.

Staple and accompanying dishes intake = serving size of the staple and accompanying dishes for each grade (g)/total number of pupils in the grade – leftover vegetables (g)/total number of pupils in the grade.

Energy intake = \((\text{energy content of a meal for grades 3 and 4} - 138 \text{ kcal}) \times (\text{intake amount of the staple and accompanying dishes for the grade/serving size of the staple and accompanying dishes of grades 3 and 4}) + 138 \text{ kcal} \times (206 \text{ g of milk} - \text{amount of leftover milk per person})/206 \text{ g}.

Error bars show the standard deviation of the total meal intake (staple food, accompanying dishes, and milk).

† Milk: Grade and month effects were analyzed by two-way analysis of variance to avoid repetition. Grade effect: *p = 0.01;* month effect: *p = 0.16.*

‡ Staple food and accompanying dishes: Grade and month effects were analyzed by two-way analysis of variance to avoid repetition. Grade effect: *p = 0.00;* month effect: *p = 0.00.*

§ Intake energy: Grade and month effects were analyzed by two-way analysis of variance to avoid repetition. Grade effect: *p = 0.00;* month effect: *p = 0.00.*

In April 2015, 15 school lunches were provided (13 for grade 1); 19 were provided in September 2015 (17 for grade 6), and 14 were provided in January 2016 (13 for grade 6).
for grade 1, 470 to 503 g for grade 2, 565 to 613 g for grade 3, 569 to 614 g for grade 4, 649 to 701 g for grade 5, and 655 to 700 g for grade 6. The milk intake for grades 1 and 2 was below 200 g, but for grades 3 to 6, the pupils drank the full amount of 206 g. Regarding the staple food and accompanying dishes, the pupils in grades 1 and 2 consumed similar amounts. For pupils in grade 3 and above, consumption gradually increased by grade. When we looked for changes among the three surveyed months, April 2015, September 2015, and January 2016, an increasing trend over the three surveyed months was observed for grades 1 and 2. However, there tended to be a slight decrease in September 2015 for grades 3 to 6, which increased in January 2016. When the intake weight by grade and month was analyzed using two-way analysis of variance to avoid repetition, a significant difference was found for grades ($p = 0.00$) and months ($p = 0.00$).

The energy intake per meal was as follows: 464 to 521 kcal for grade 1, 517 to 528 kcal for grade 2, 628 to 641 kcal for grade 3, 628 to 647 kcal for grade 4, 714 to 742 kcal for grade 5, and 733 to 751 kcal for grade 6. The energy intake by grade and month was analyzed using two-way analysis of variance to avoid repetition, and a significant difference for grades ($p = 0.00$) and months ($p = 0.00$) was found.

4. Estimated energy requirements

Figure 3 shows the distribution of the dietary reference intake (target energy) of lunch determined from an assessment of the pupils' body compositions and EER33%.

The EER33% for April was reevaluated and found to be

![Figure 3](image_url)

**Figure 3** Cumulative frequencies of 33% of estimated energy requirements by grade

In April 2015, $n$ (number of pupils) = 427; in September 2015, $n = 429$; and in January 2016, $n = 423$. 
554 kcal after revising the range of pupils to include the median ± standard deviation × 2. Twenty-six pupils required individual counseling and support. The EER33% for September was reevaluated and found to be 589 kcal after revising the range of pupils to include the median ± standard deviation × 2. Twenty-one pupils required individual counseling and support. The EER33% for January was reevaluated and found to be 603 kcal after revising the range of pupils to include the median ± standard deviation × 2. Twenty pupils required individual counseling and support. The dietary reference intake (energy content), in other words, the EER33%, for all the pupils at A Elementary School was below the Nutritional Standards of 640 kcal for 8- to 9-year-olds.

Table 2 shows the EER33%, energy served, and energy intake from a school lunch meal. In terms of grade groups, the EER33% tended to increase as the grades got higher (Table 2). As for the changes from April to September, each of the three grade groups increased by 26 to 46 kcal. As for the changes from September to January, the grades 1 and 2 and the grades 3 and 4 groups increased by 4 to 14 kcal. However, the representative value decreased by 38 kcal in the grades 5 and 6 group because of a decline in energy storage.

The amount of energy served at lunch (Table 2) was higher than the EER33% for all grade groups and surveyed months. In terms of energy intake (Table 2), because of the plate waste in grades 1 and 2, the amount of energy served decreased by 25 to 51 kcal. The energy served in grades 3 to 6 was approximately the same, indicating that the children ate all the food that was served to them at lunch.

### IV. Discussion

The school’s food service management system began planning 2 months before the commencement of the school lunch program, and hence, the EER33% was determined once the school lunch services began, leading to a time lag in conducting the nutritional assessments. Consequently, the service standard of nutrient targets proposed by the local government was used as a reference to establish the energy targets that matched A Elementary School. We were able to observe one portion of the nutrition and meal management system operated under the PDCA cycle. The planning of the school lunch meals was conducted through nutrition and meal planning, quality planning, food service system planning, and menu con-

**Table 2** Median of 33% estimated energy requirements and means of energy served and intake by grade and month, and the energy targets for school lunches (kcal/meal)

| Grade (age in years) | 1st–2nd (6–7 years) | 3rd–4th (8–9 years) | 5th–6th (10–11 years) | 3rd–4th (8–9 years) |
|----------------------|----------------------|----------------------|------------------------|----------------------|
| EER                  | ES       | EI       | EER                  | ES       | EI       | EER                  | ES       | EI       | ET       |
| April 2015           |          |          |                      |          |          |                      |          |          |          |
| (n)                  | (154)    | (28)    | (28)                 | (153)    | (30)    | (30)                 | (120)    | (30)    | (30)    |
| September 2015       | (n)      | (156)   | (38)                 | (154)    | (38)    | (38)                 | (119)    | (36)    | (36)    |
| January 2016         | (n)      | (155)   | (28)                 | (152)    | (28)    | (28)                 | (116)    | (27)    | (27)    |

EER: median of 33% of estimated energy requirements. The EER value is the median value.

ES: mean of energy served, EI: mean of energy intake. The ES and EI are shown as mean ± standard deviation.

ET: the energy target for school lunches.

The numbers in parentheses (n) are the sample sizes used in the calculation. EER is the total number of pupils. ES and EI show the number of served school meals.

ES: (energy served for grades 3 and 4 – 138 kcal) × (serving size of the staple food and accompanying dishes per person in each grade/average serving size of the staple food and accompanying dishes per person in grade 3 and 4) + 138 kcal.

EI: (energy served for grades 3 and 4 – 138 kcal) × (intake amount of the staple food and accompanying dishes per person in each grade/average serving size of the staple food and accompanying dishes per person in grades 3 and 4) + 138 kcal × (206 g of milk–amount of leftover milk per person)/206 g.
trols, followed by food ingredient management, management of production and services, and provision of school meals. The quality of school meals was assessed according to consumption status (plate waste). Improvement (A for the PDCA cycle) was based on daily experiences. In the future, accumulated nutritional assessment information through EER calculation software could provide a proactive food service management system based on scientific evidence.

The weight of the served meals significantly increased as the grades got higher. In terms of months, the weight was 0.02 to 0.03 kg lower in September than in April. This may have occurred as a result of trying to adjust the figures to be closer to the energy targets for school lunches, since the frequency of the deep-fried food on the September menu was 37% (seven of 19 meals), higher than that in April (33%; five of 15 meals) and January (29%; four of 14 meals).

Regarding the amount of intake, the new grade 1 pupils in April seemed to struggle to finish all the food they were served; however, by September, they were able to consume as much as the grade 2 pupils. On a separate note, finishing the whole 206 g carton of milk (portion size) was an issue. Taking into consideration that April is the first time pupils have a school lunch meal, we may need to reconsider the amount of food per meal in April and consider measures such as combining more soup-based dishes and gradually increasing the serving size.

The EER33% values calculated from the nutritional assessment of height and body weight obtained from the health checkups in April, September, and January were lower than the 640 kcal (for 8- and 9-year-olds) established by Japanese nutritional standards. However, considering past data on plate waste, the slightly low of energy targets for school lunches was proven to be appropriate. The energy targets for school lunches was set higher than the EER33% of grades 3 and 4 (table2, 620 kcal/573 kcal, 640 kcal/609 kcal, 660 kcal/613 kcal). Assuming that the energy targets for school lunches obtained from the EER33% of grades 3 and 4 was 100%, that for grades 1 and 2 in April was 85% (487 kcal/513 kcal) and for grades 5 and 6 was 122% (703 kcal/573 kcal). In January, the figures were slightly higher for grades 1 to 4 and lower for grades 5 and 6: 103% for grades 1 and 2 (527 kcal/513 kcal), 101% for grades 3 and 4 (613 kcal/609 kcal), and 95% for grades 5 and 6 (711 kcal/749 kcal). This increase in the monthly comparison was observed in grades 1 to 4, and there was a clear sign of growth of the children from April. However, for grades 5 and 6, although there was an increase from April to September, the figures decreased between September and January. This may be an effect of decreased basal metabolism and energy storage as, according to age group, they are considered to be 12-year-olds in January.

A previous study reported that the energy retention rate of nutrient content per meal depicted in the quality plan of school meals was approximately 85% owing to
water and fat loss through heating in the cooking and production process. The provision and intake of energy outlined on the quality plan of the school meals investigated in this study was slightly higher than the EER33%. Considering the energy retention rate during production, we can say that it was adequate energy content. As described above, the quality control of the school lunch program at A Elementary School was properly operated from the perspective of nutrition and meal management.

Although the implementation rate of school lunch programs in Japan is over 99%, a limitation of this study was the fact that it presented only the current food service and nutritional management practices of one elementary school; it is possible that other elementary schools have different food service management practices. In addition, as the serving sizes and energy intakes for the different grades and months were shown as mean values, the process of obtaining a representative EER value did not consider the amounts that are required by pupils with individualized needs or those with food allergies. In the future, to understand and compare current practices in various food service management systems at various schools and include the nutritional management of pupils with individualized needs, a more detailed investigation is required.

V. Conclusion

The food service management system at A Elementary School determined the energy targets for school lunches 2 months before starting the school lunch program. To develop the plan for the school lunch program, the energy targets for school lunches were calculated based on the service standard of energy targets proposed by the local government, and these targets were revised regularly three times per year, starting in April (April, September, and January) to accommodate the pupils’ growth. The menu planning process used the energy targets for grades 3 and 4 as a reference and multiplied by conversion factors (80% for grades 1 and 2; 120% for grades 5 and 6) to determine the amount of meals to be produced and served.

The EER33% of A Elementary School was slightly lower than the energy content of Japanese nutritional standards. The energy served in the school meals was higher than the EER33%, and although there was some plate waste observed in grades 1 and 2, the energy intake met the EER33%, indicating that the nutrition and meal management of the pupils was adequate.

This study also revealed that it takes approximately 6 months for new grade 1 pupils to get used to the serving size of school meals, suggesting that measures may be needed in creating menus. In the future, when setting the energy targets for school lunches, individualized attention needs to be paid to pupils whose requirements deviate from the EER33%, and special care for pupils with food allergies needs to be considered.

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Conflict of Interest

The authors declare no conflict of interest related to this study.

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