Negative Association in Reported Dietary Energy Intake and Physique in Japanese Schoolchildren

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(Received December 21, 2019)

Summary Appropriate dietary assessment and health education are necessary for children to achieve a healthy physique. To explore the relationship between habitual reported dietary energy intake (EI) and physique in elementary schoolchildren by sex and age, we conducted a longitudinal study, in the fiscal year 2011, that included all elementary schools in Omihachiman City, Shiga Prefecture, Japan. The study lasted for four consecutive years, ending in fiscal year 2014, and included 545 7-y-old schoolchildren in the target city. The subjects completed a brief self-administered diet history questionnaire with their guardians. The results of the study demonstrated a negative relationship between energy intake and the estimated energy requirement ratio and body mass index percentile values for both 7-, 9-, and 10-y-old boys and 7- to 10-y-old girls. These results suggest that there is a need to keep in consideration the under-reporting of obese children and over-reporting of lean children for dietary energy evaluation.

Key Words brief diet history questionnaire, energy intake, estimated energy requirement, physiques, schoolchildren

In recent years, we have witnessed the emergence of a worldwide nutritional problem, which has become known as the double burden of malnutrition (DBM) (http://apps.who.int/iris/bitstream/10665/255413/1/WHO-NMH-NHD-17.3-eng.pdf), a situation where overnutrition and under-nutrition both exist simultaneously in the same society. Even in Japan, obesity in adult men and excessive leanness in young women have become serious health issues (1, 2). However, it has not been determined exactly when these health issues develop. It has previously been reported (3) that obesity in children can lead to an increased risk of diabetes, dyslipidemia, hypertension, and cardiovascular diseases in the future. In Japan, the issue of malnutrition has been gradually improving after World War II. In 1965, The Japan Pediatric Society held a panel discussion on the topics of children’s obesity, treatment of severely obese children in university pediatrics clinics, and care for slightly or mildly obese children as implemented in the school health care systems in Kyoto City (4). On the other hand, in regard to the tendency for young women’s excessive leanness, it has been pointed out that, in addition to anemia, abnormal menstruation, and a lower peak bone mass, there are several related health problems that may arise in the future, such as the risk of delivering low birthweight infants (5–7). There are several possible causes of excessive leanness, such as mistaken information or perceptions on what a desirable physique or figure looks like via friends or the mass media, and inappropriate dietary habits in accordance with that (8). In this regard, it is important for schools and local regional health promotion programs to implement educational measures in sufficient numbers and scope.

According to the report conducted by the Ministry of Education, Culture, Sports, Science and Technology in 2016, published in fiscal year 2018 as the “Annual report of school health statistics research 2016” (in Japanese) (http://www.mext.go.jp/b_menu/toukei/chou sa05/hoken/kekka/k_detail/1411711.htm), concerning Japanese schoolchildren, both boys and girls, aged 6- to 8-y-old, the overall percentage of obesity in children was 5.89%, with boys showing a higher percentage at 6.23% and girls at 5.53%. The overall percentage

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of excessive leanness in children was 0.46%, with boys at 0.39% and girls showing a higher percentage at 0.53%.

In 2013, the Ministry of Health, Labour and Welfare published a report on public health promotion in the 21st century known as “Health Japan 21 (the second term)” (in Japanese) (https://www.mhlw.go.jp/bunya/kenkou/dL/kenkounippon21_01.pdf), which aimed that the incidence of elementary schoolchildren in the 5th grade with an intermediate or high tendency for obesity was declining (in 2013, boys showed 5.14% and girls showed 3.48%). According to the document published by the Ministry of Health, Labour and Welfare, known as the “Healthy Parents and Children 21” (in Japanese) (http://rhino.med.yamanashi.ac.jp/sukoyaka/saisyuuhyouka.html), the organization aimed to reduce the frequency of unhealthy leanness in female adolescents (with an obesity degree of −15% or lower, given that the subject’s weight was lower than 1 standard deviation on the growth curve). However, in 2002, the percentage of unhealthy leanness in girls in their 3rd year of junior high school was 5.5%, showing an increase, and in 2013, that figure further increased to 19.6%. In the academic realm, there is a lack of organizations and programs that have been established to achieve this objective of reducing the frequency of unhealthy leanness. In addition, The Ministry of Education, Culture, Sports, Science and Technology has also not defined any definite goals to combat excessive leanness in female adolescents.

To achieve a healthy physique and lifestyle, it is necessary to maintain an appropriate dietary energy intake (EI). According to the “Dietary reference intakes for Japanese, 2015” (9) published by the Ministry of Health, Labour and Welfare, the evaluation of EI should be based on the subject’s physique and not on their dietary records. However, to provide individual dietary guidance and food intake volume allowances for school lunches designed to improve obesity or excessive leanness, it is necessary to assess energy, nutrients, and food group intakes of schoolchildren accurately.

There have been reports on the underreporting of EI in dietary assessments in obese adults and women (10–12). Livingstone and Black reviewed studies on misreporting of energy intake among children and adolescents (13). Among the young western population, the percentage of under-reporting of EI, has ranged from 5–52% and that of over-reporting has been from 0–46% (14, 15). Especially for 16- to 17-y-old teenagers, there was a highly significant negative association between BMI and reporting of EI by questionnaire (14).

There were two reports on the dietary assessment of energy intake in Japanese children and adolescents (16, 17) with the percentage of under-reporting of EI at 31.6%, and that of over-reporting from 15.2%, using a self-administered diet history questionnaire (16) and the National Health and Nutrition survey by one day semi-weighed dietary assessment. Both reports exemplified the negative association between reporting of EI and physique (17) in both sexes aged 1- to 19-y-old, but the reporting of EI in elementary schoolchildren remained unclear.

To evaluate the relationship between habitual reported dietary EI and physique in elementary schoolchildren by sex and age, we used the data collected in a 4 y longitudinal survey that was previously performed to investigate the effect of various lifestyle factors on allergic symptoms as part of the Lifestyle and Allergy among Kids in Elementary school (LAKE) study (18, 19). This study was approved by the Institutional Review Board of Kyoto University, Graduate School of Medicine (E939), and Kyoto Prefectural University of Medicine (ERB-C-1270). All procedures were conducted in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. In each case, parental responses to the questionnaires were taken as informed consent only these subjects were considered eligible for the study.

**Assessment of energy intake from a questionnaire.** We used the BDHQ-10y for Japanese elementary schoolchildren (16, 20–23). It was designed to assess dietary history for a one-month period in Japanese elementary

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**MATERIALS AND METHODS**

**Subjects.** This was a longitudinal study that included all 12 elementary schools in Omiyachimian City, Shiga Prefecture, Japan. A total of 645 subjects were recruited from a cohort of 759 7-y-old schoolchildren, and these subjects were prospectively registered every year for four consecutive years from fiscal year 2011–2014. All participants took school lunches at schools. We distributed a brief self-administered diet history questionnaire for elementary schoolchildren (BDHQ-10y) to schoolchildren in each elementary school class. The subjects’ parents were asked to answer each questionnaire according to their children’s diet (BDHQ-10y) along with their children at home. The written questionnaires were collected at schools by the teachers. We excluded data from 100 subjects who did not provide enough information in the questionnaire or regarding their body mass index (BMI). We included data from a total of 545 subjects (71.8%, 254 boys and 291 girls) in the analyses (Fig. 1). The details of recruitment and enrollment employed in the study were described previously (19).

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Table 1. Physical characteristics of the schoolchildren by sex and age (n=545).

| Age (y) | Boys (n=254) | Girls (n=291) |
|---------|--------------|---------------|
|         | Body height (cm) | 127.3 (5.2) | 125.6 (5.2) |
| 7       | 132.7 (5.5) | 131.4 (5.5) |
| 8       | 137.9 (5.7) | 137.8 (6.4) |
| 9       | 143.8 (6.5) | 144.8 (6.6) |
| 10      | <0.001       | <0.001       |
| BMI percentile | 48.4 (26.7) | 48.4 (26.7) |
| <5th n (%) | 8 (3.0) | 8 (3.0) |
| 5th–95th n (%) | 236 (93.0) | 236 (93.0) |
| ≥95th n (%) | 10 (4.0) | 10 (4.0) |
| EI (kcal/d) | 1,986 (524) | 1,744 (430) | 1,286 (124) | 1,37 (0.36) |
| EER (kcal/d) | 1,551 (126) | 1,664 (144) | 1,17 (0.26) | 1,12 (0.26) |
| BMI percentile | 48.4 (26.7) | 48.4 (26.7) |
| <5th n (%) | 8 (3.0) | 8 (3.0) |
| 5th–95th n (%) | 236 (93.0) | 236 (93.0) |
| ≥95th n (%) | 10 (4.0) | 10 (4.0) |
| Body weight (kg) | 26.2 (4.3) | 25.1 (4.2) | 25.1 (4.2) |
| EI/EER | 1.29 (0.35) | 1.28 (124) | 1.28 (124) |
| EER (kcal/d) | 1,551 (126) | 1,664 (144) | 1,17 (0.26) | 1,12 (0.26) |
| BMI percentile | 48.4 (26.7) | 48.4 (26.7) |
| <5th n (%) | 8 (3.0) | 8 (3.0) |
| 5th–95th n (%) | 236 (93.0) | 236 (93.0) |
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Data are shown as mean (SD) or n (%).
1 Significant difference between age groups (ANOVA).
2 Significant difference between age groups in all categories (Fisher’s exact test).
EI, energy intake; EER, estimated energy requirement; BMI, body mass index.

The dietary assessment by the BDHQ-10y was conducted in September, and the results of the school health checkup conducted in January every year were used as part of the physical assessment. Body height and weight were measured to the nearest 0.1 cm and 0.1 kg using a digital scale with children wearing light clothes with their shoes removed. BMI was calculated as weight (kg) divided by the square of body height (m²) with age- and sex-specific BMI percentiles calculated using the Excel-based clinical tools for growth evaluation of children (http://jspe.umin.jp/medical/files_chart/taikakushisu_v3.3.xlsx), which was based on the 2000 National Growth Survey on Pre-school Children and School Health Statistics Research.

Estimation of the energy requirement. The energy requirement (EER) of each subject was estimated for the predicted basal metabolic rate (BMR) multiplied by physical activity level (PAL). The predictive BMR was calculated using the Ganpule equations (25), and the normal PAL of 1.75 for Japanese (9) was used for the calculations.

Statistical analysis. We calculated the EI/EER ratio to assess the validity of the reported EI adjusted by body weight for each year. The subjects were classified by age and quintile of the EI/EER ratio to compare “low intake reporters” with “high intake reporters.” Low EI/EER ratios indicated that the reported EI was relatively lower than the energy requirement of the related subject. Physical characteristics, that is, age (mo), height, weight, EI, EER, BMI percentile, and categorical portion of BMI percentile, <5th, 5th–95th, ≥95th by the quintile of the EI/EER ratio, was addressed separately for each age group by sex. A multivariate evaluation of the simultaneous effect of the BMI percentile and age (mo) on the EI/EER ratios was performed by a multiple linear regression analysis for each age group.

All statistical analyses were performed with R version 3.4.3 (R Foundation for Statistical Computing, Vienna, Austria). p<0.05 was considered to be statistically significant. Unless otherwise stated, the results were presented as means (SD). Differences between groups were assessed by one-way analysis of variance (ANOVA) and Dunnett’s post hoc test (26) or Fisher’s exact test.

RESULTS

Table 1 shows a summary of the physical characteristics of boys and girls aged 7–10 y old. Results showed...
Table 2. Physical characteristics by the quintile of the EI/EER ratio of boys by age (n=254).

| Age (y) | Variable                  | Boys  | p-value^1 |
|--------|---------------------------|-------|-----------|
|        | First quintile (n=51)     |       |           |
|        | Second quintile (n=51)    |       |           |
|        | Third quintile (n=50)     |       |           |
|        | Fourth quintile (n=51)    |       |           |
|        | Fifth quintile (n=51)     |       |           |
| 7      | EI/EER                    |       |           |
|        | Age (mo)                  | 0.91  | 0.12      |
|        | Body height (cm)          | 128.3 | 0.001     |
|        | Body weight (kg)          | 27.2  | 0.001     |
|        | EI (kcal/d)               | 1.433 | 0.001     |
|        | EER (kcal/d)              | 1.581 | 0.001     |
|        | BMI percentile            |      | 0.001     |
| <5th   | n (%)                     | 3 (6.0) | 0.001  |
| 5th–9th| n (%)                     | 44 (86.0) | 0.001 |
| ≥95th  | n (%)                     | 4 (8.0) | 0.001   |
| 8      | EI/EER                    | 0.86  | 0.42      |
|        | Age (mo)                  | 108.1 | 0.001     |
|        | Body height (cm)          | 134.2 | 0.001     |
|        | Body weight (kg)          | 31.2  | 0.001     |
|        | EI (kcal/d)               | 1.466 | 0.001     |
|        | EER (kcal/d)              | 1.715 | 0.001     |
|        | BMI percentile            |      | 0.13      |
| <5th   | n (%)                     | 0 (0.0) | 0.001  |
| 5th–9th| n (%)                     | 46 (90.0) | 0.001 |
| ≥95th  | n (%)                     | 5 (10.0) | 0.001   |
| 9      | EI/EER                    | 0.80  | 0.42      |
|        | Age (mo)                  | 119.1 | 0.001     |
|        | Body height (cm)          | 141.0 | 0.001     |
|        | Body weight (kg)          | 36.4  | 0.001     |
|        | EI (kcal/d)               | 1.507 | 0.001     |
|        | EER (kcal/d)              | 1.879 | 0.001     |
|        | BMI percentile            |      | 0.025     |
| <5th   | n (%)                     | 0 (0.0) | 0.001  |
| 5th–9th| n (%)                     | 47 (92.0) | 0.001 |
| ≥95th  | n (%)                     | 4 (8.0) | 0.001   |
| 10     | EI/EER                    | 0.75  | 0.008     |
|        | Age (mo)                  | 132.5 | 0.001     |
|        | Body height (cm)          | 148.0 | 0.001     |
|        | Body weight (kg)          | 40.9  | 0.001     |
|        | EI (kcal/d)               | 1.510 | 0.001     |
|        | EER (kcal/d)              | 2.031 | 0.001     |
|        | BMI percentile            |      | 0.032     |
| <5th   | n (%)                     | 0 (0.0) | 0.001  |
| 5th–9th| n (%)                     | 47 (92.0) | 0.001 |
| ≥95th  | n (%)                     | 4 (8.0) | 0.001   |

Data are shown as mean (SD) or n (%).

^1 Significant difference between quintile of EI/EER ratio (ANOVA).

^2 Significant difference between quintile of EI/EER ratio in all categories (Fisher’s exact test).

Significance difference compared with the first quintile of EI/EER (Dunnett’s test); *p<0.05.

EI, energy intake; EER, estimated energy requirement; BMI, body mass index.

that body height, weight, and EER increased with age in both sexes. No differences were shown in EI between age groups of either sex. On the other hand, the EI/EER ratio decreased with increasing age in both sexes; the means (SD) of the EI/EER ratios for 10-y-old boys and girls were 1.04 (0.27) and 0.99 (0.26), respectively. EI estimated by BDHQ-10y is based on the Japanese 10-y-old dietary intake; hence the EI/EER ratio also approached 1.0 in both sexes. No differences were observed in the BMI percentile or in the distribution among age groups of either sex.

Tables 2 and 3 show the physical characteristics
of the subjects classified by age and the quintile of the EI/EER ratio for boys and girls, respectively. There were significant differences in body height, weight, EI, EER, and BMI percentile by the quintile of the EI/EER ratio groups in 7- to 10-y-old subjects of both sexes, which was confirmed by ANOVA. Body height, weight, and BMI percentile decreased as the quintile of the EI/EER ratio increased to the 5th quintile group in 7- to 10-y-old subjects, and statistically significant differences in age (mo) among the quintile of the EI/EER ratio were observed in 8- and 10-y-old subjects of both sexes. The BMI percentile of the 1st quintile was significantly lower

| Age (y) | Variable | First quintile (n=58) | Second quintile (n=58) | Third quintile (n=58) | Fourth quintile (n=58) | Fifth quintile (n=59) | p-valuea |
|---------|-----------|----------------------|-----------------------|----------------------|-----------------------|----------------------|---------|
| 7 EI/EER | Age (mo)  | 0.97 (0.13)          | 1.19 (0.04)           | 1.30 (0.04)          | 1.46 (0.06)           | 1.91 (0.36)          |         |
|         | Body height (cm) | 127.8 (4.9)       | 126.5 (4.9)           | 125.6 (5.1)          | 124.7 (5.4)*          | 123.5 (5.1)*         | <0.001  |
|         | Body weight (kg) | 27.5 (4.9)        | 25.4 (3.2)*           | 25.0 (3.8)*          | 24.6 (4.9)*           | 23.2 (2.7)*          | <0.001  |
|         | EI (kcal/d) | 1.314 (126)         | 1.546 (134)*          | 1.673 (163)*         | 1.842 (193)*          | 2.334 (454)*         | <0.001  |
|         | EER (kcal/d) | 1.355 (130)         | 1.299 (104)*          | 1.282 (118)*         | 1.266 (134)*          | 1.226 (97)*          | <0.001  |
|         | BMI percentile | 56.2 (26.7)        | 47.3 (22.2)           | 46.1 (23.6)          | 42.8 (26.0)*          | 36.4 (21.4)*         | <0.001  |
|         | 5th–95th n (%) | 51 (88.0)           | 57 (98.0)             | 54 (93.0)            | 55 (95.0)             | 57 (97.0)            | 0.005   |
|         | 95th n (%) | 7 (12.0)             | 0 (0.0)               | 1 (2.0)              | 1 (2.0)               | 0 (0.0)              |         |
| 8 EI/EER | Age (mo)  | 0.88 (0.09)          | 1.06 (0.04)           | 1.18 (0.04)          | 1.31 (0.04)           | 1.69 (0.32)          |         |
|         | Body height (cm) | 133.4 (4.9)        | 131.8 (5.7)           | 132.1 (4.6)          | 131.3 (5.7)           | 128.2 (5.5)*         | <0.001  |
|         | Body weight (kg) | 30.8 (6.1)         | 28.6 (4.6)            | 27.8 (3.5)*          | 28.0 (6.0)*           | 26.0 (3.6)*          | <0.001  |
|         | EI (kcal/d) | 1.288 (187)         | 1.493 (164)*          | 1.647 (144)*         | 1.824 (211)*          | 2.234 (440)*         | <0.001  |
|         | EER (kcal/d) | 1.469 (157)         | 1.410 (138)           | 1.396 (107)*         | 1.393 (160)*          | 1.322 (116)*         | <0.001  |
|         | BMI percentile | 54.1 (28.0)        | 48.5 (23.7)           | 41.8 (23.4)*         | 42.5 (24.4)*          | 40.2 (24.0)*         | <0.001  |
|         | 5th–95th n (%) | 5 (92.0)            | 57 (98.0)             | 55 (95.0)            | 54 (93.0)             | 58 (98.0)            |         |
|         | 95th n (%) | 6 (10.0)             | 1 (2.0)               | 0 (0.0)              | 1 (2.0)               | 0 (0.0)              |         |
| 9 EI/EER | Age (mo)  | 0.81 (0.08)          | 0.96 (0.03)           | 1.08 (0.03)          | 1.20 (0.04)           | 1.51 (0.26)          |         |
|         | Body height (cm) | 141.6 (4.63)        | 139.2 (6.3)           | 137.3 (6.5)          | 136.8 (5.4)*          | 134.0 (6.4)*         | <0.001  |
|         | Body weight (kg) | 37.1 (7.9)          | 34.1 (6.0)*           | 30.6 (4.5)*          | 29.9 (4.2)*           | 28.8 (4.3)*          | <0.001  |
|         | EI (kcal/d) | 1.342 (177)         | 1.519 (166)*          | 1.621 (162)*         | 1.773 (166)*          | 2.169 (456)*         | <0.001  |
|         | EER (kcal/d) | 1.670 (184)         | 1.586 (166)*          | 1.500 (144)*         | 1.481 (127)*          | 1.431 (140)*         | <0.001  |
|         | BMI percentile | 59.0 (27.9)        | 53.4 (25.6)           | 38.6 (24.3)*         | 35.2 (23.7)*          | 36.6 (23.3)*         | <0.001  |
|         | 5th–95th n (%) | 5 (92.0)            | 54 (93.0)             | 52 (95.0)            | 53 (91.0)             | 54 (92.0)            |         |
|         | 95th n (%) | 7 (12.0)             | 3 (5.0)               | 0 (0.0)              | 0 (0.0)               | 0 (0.0)              |         |
| 10 EI/EER | Age (mo)  | 0.72 (0.08)          | 0.86 (0.02)           | 0.95 (0.03)          | 1.07 (0.04)           | 1.36 (0.28)          |         |
|         | Body height (cm) | 147.3 (6.0)        | 146.5 (6.1)           | 144.1 (5.9)*         | 144.2 (6.7)*          | 141.9 (6.9)*         | <0.001  |
|         | Body weight (kg) | 40.6 (8.2)         | 37.2 (6.3)*           | 35.8 (5.9)*          | 35.2 (5.4)*           | 33.9 (8.1)*          | <0.001  |
|         | EI (kcal/d) | 1.287 (181)         | 1.467 (155)*          | 1.578 (154)          | 1.768 (188)*          | 2.188 (540)*         | <0.001  |
|         | EER (kcal/d) | 1.792 (196)         | 1.714 (175)           | 1.662 (166)*         | 1.654 (164)*          | 1.606 (211)*         | <0.001  |
|         | BMI percentile | 54.8 (30.1)        | 42.5 (24.1)*          | 42.1 (25.8)*         | 38.8 (24.6)*          | 34.3 (25.9)*         | <0.001  |
|         | 5th–95th n (%) | 49 (84.0)           | 55 (95.0)             | 56 (97.0)            | 56 (97.0)             | 52 (88.0)            |         |
|         | 95th n (%) | 8 (14.0)             | 0 (0.0)               | 0 (0.0)              | 0 (0.0)               | 1 (2.0)              |         |

Data are shown as mean (SD) or n (%).

1 Significant difference between quintile of EI/EER ratio (ANOVA).
2 Significant difference between quintile of EI/EER ratio in all categories (Fisher’s exact test).

Significance difference compared with the first quintile of EI/EER (Dunnett’s test): *p<0.05.

EI, energy intake; EER, estimated energy requirement; BMI, body mass index.
than the 5th quintile in 9- to 10-y-old boys, whereas it was significantly lower in 7- to 10-y-old girls. Similarly, the association of the categorical portion of the BMI percentile significantly differed among the EI/EER quintiles in 9- to 10-y-old boys, but the association of the categorical portion of the BMI percentile significantly differed in 7- to 10-y-old girls.

Table 4 shows the results of the multiple regression analysis with the EI/EER ratios as dependent variables by age and sex. The BMI percentile and age (mo) showed a significant negative association with EI/EER ratio; hence they were included in the model. In boys, the BMI percentile was significantly negatively correlated in 7- to 10-y-old girls, whereas, in girls, the BMI percentile was significantly negatively correlated with the EI/EER ratio in 7- to 10-y-old subjects.

**DISCUSSION**

This was a longitudinal study on EI for four consecutive years among Japanese elementary schoolchildren (from 7–10 y old) aimed to evaluate the relationship between EI and BMI. The results highlighted a negative association between EI/EER ratio and physique of 7-, 9-, and 10-y-old boys and 7- to 10-y-old girls. It indicates that overweight children tend to report relatively under-intake and lean children tend to report over-intake.

These results were similar to the results of previous studies highlighting negative relationship between BMI and EI, among western and Japanese children and adolescents (13–17), young Japanese women (27), and other Japanese adults over the age of 30 y who were assessed by various methods (28, 29). Overweight and obese children were seen to under-reporting their dietary intake (30).

A number of reports have been published concerning the elementary cause of under-reporting of dietary EI, other than physique, including sex, age, excessive weight gain and diet trials (12), smoking, psychological state, socioeconomic status, self-image, and lifestyle state, socioeconomic status, self-image, and lifestyle (30–34). However, there are few studies concerning over-reporting in lean females.

According to a study done by Vagstrand et al. that assessed 16- to 17-y-old Swedish teenagers through a questionnaire (14), there was a highly significant negative association between BMI and reporting EI. Murakami et al. examined the characteristics of under-reporting and over-reporting of EI in Japanese children and adolescents aged 6- to 15-y old using a brief self-administered diet history questionnaire (BDHQ)-CA. The percentage of under-reporters was 31.6% and that of over-reporting was 15.2%. Under-reporting was associated with the female sex, older age (10- to 15-y-old), overweight and obese, low parental education, and completion of the dietary questionnaire without the cooperation of parents. Over-reporting was associated with younger age (1- to 5-y-old), normal weight, low parental education, and completion of the dietary questionnaire without the cooperation of parents (16).

Murakami et al. also investigated the under- and over-reporting of energy intake in boys and girls aged 1- to 19-y-old using the 2012 National Health and Nutrition Survey and concluded that there was a significant negative association between EI/EER and weight status that ranged from thin and normal to overweight and obese (17). But the characteristics of under- and over-reporting were not clear in schoolchildren according to gender. According to the National Health and Nutrition Survey, the percentage of lean, young females was 20%. The dietary assessments were insufficient among children and adolescents in elementary and junior high schools. Further dietary assessments and education by school dietitians are required to achieve the aim of healthy physique from childhood through school lunches.

**Table 4. Multiple regression analysis with the EI/EER ratio as dependent variables by age and sex.**

| Age (y) | Variable | Boys (n=254) | Girls (n=291) |
|--------|----------|--------------|---------------|
|        | β value  | Standard Error | 95% CI | p-value | β value  | Standard Error | 95% CI | p-value |
| 7      | Intercept | 2.066 | 0.578 |                  | 2.107 | 0.584 |                  |
|        | BMI percentile | -0.002 | 0.001 | -0.004–0.000 | 0.011 | -0.003 | 0.001 | -0.005–0.002 | <0.001 |
| 8      | Intercept | 2.899 | 0.485 |                  | 1.537 | 0.588 |                  |
|        | BMI percentile | -0.001 | 0.001 | -0.002–0.000 | 0.066 | -0.002 | 0.001 | -0.004–0.001 | 0.004 |
| 9      | Intercept | 1.499 | 0.563 |                  | 2.388 | 0.547 |                  |
|        | BMI percentile | -0.002 | 0.001 | -0.003–0.001 | 0.002 | -0.003 | 0.001 | -0.004–0.001 | <0.001 |
| 10     | Intercept | 2.599 | 0.611 |                  | 1.927 | 0.582 |                  |
|        | BMI percentile | -0.002 | 0.001 | -0.003–0.001 | <0.001 | -0.002 | 0.001 | -0.003–0.001 | 0.004 |
|        | Age (mo) | -0.011 | 0.005 | -0.020–0.002 | 0.017 | -0.007 | 0.004 | -0.015–0.002 | 0.138 |

EI, energy intake; EER, estimated energy requirement; BMI, body mass index; β, regression coefficient; CI, confidence interval.
By the “Basic Act on Food Education” in Japan (35), nutrition education should be conducted so that children acquire correct and sufficient knowledge about healthy meals and positive eating habits. Judging from the results of this study, it can be considered that nutrition education about appropriate EI from school lunches should be conducted from early grades in elementary schools.

This study has several limitations. First, in regard to maintaining feasibility and validity while obtaining habitual dietary intake among subjects, we used the BDHQ-10y to collect self-reported dietary assessments. In 2016, a brief self-administered diet history questionnaire for Japanese children and adolescents (BDHQ-15y) without the item of school lunch, was developed instead of BDHQ-10y for the use of schoolchildren and adolescents. Murakami et al. has reported that, when only children answered the BDHQ-10y by themselves, the validity was insufficient. This study was conducted under school lunch system and both the children and parent’s cooperation. The limitation of this study’s result should not be influenced by the limitation of the BDHQ-10y. The BDHQ-10y includes 54 selected foods and beverage items. If the participants prefer to eat uncommon foods that are not included in the BDHQ-10y, the estimation of dietary intake might be insufficient. Second, we could not obtain PAL of the subjects, and we applied a value of 1.75 for all of them. This limited the range of the EI/EER ratios, and thus there is the possibility that the negative association between dietary EI and physique has been underestimated.

The strength of this study was that it recruited all 7- to 10-y-old schoolchildren in Omihachiman City and there was a high response rate of 71.8% as part of the population representativeness. In addition, we were able to study the relationship between dietary EI and physique in the same group of subjects for 4 y in longitudinal order.

In conclusion, the negative relationship between EI and physique was observed in 7-, 9-, and 10-y-old boys and 7- to 10-y-old girls. These results suggest that there is a need to give sufficient consideration to under-reporting among obese boys and girls and over-reporting of dietary EI in lean children, especially in girls, when assessing the dietary intake of schoolchildren.

Authorship
Research conception and design: AH and KY; acquisition of data: TK, AH, MK, and HT; statistical analysis of the data: KY, AH, and MK; interpretation of the data: all authors; writing of the manuscript: AH and KY.

Acknowledgments
We thank the schoolchildren and their parents for their participation and the members of the Omihachiman City Board of Education for their contributions to this study. This work was supported by the Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Number JP 22590586. Finally, we thank Enago (www.enago.jp) for the English language review.

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