Association between motor skills and a healthy diet: a cross-sectional study of first-grade schoolchildren in Japan

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Abstract

Background: Childhood motor skills are important not only for the physical and mental health of children, but also for the prevention of future lifestyle diseases. This study aimed to investigate how motor skills among first-grade children in Japan are associated with dietary and lifestyle habits, after adjustment for various confounding factors.

Methods: First-grade children (aged 6-7 years) attending three public elementary schools in Tokyo, Japan (n=884), participated in this cross-sectional study. Homeroom teachers distributed self-administered questionnaires to parents and children. Questionnaires focused on lifestyle habits and required completion of a 1-day dietary record of meals that children ate at home. School lunch consumption was also assessed. Motor skills were measured by the New Physical Fitness Test (NPFT). Physique was calculated using Rohrer's index formula: weight (kg) / height (cm) $^{3} \times 10^{7}$. Multiple regression analysis was used to investigate the association between NPFT score and determinant factors. We also examined the association between NPFT score and the amount of energy derived from a healthy diet versus snacks.

Results: NPFT scores were significantly and positively correlated with involvement in exercise lessons (boys, β = 0.131, P = 0.006; girls, β = 0.121P = 0.012), total energy intake (boys, β = 0.096, P = 0.041; girls, β = 0.145, P = 0.003), and outside playtime in boys (β = 0.135), and negatively correlated with Rohrer's index in girls (β = -0.097, P = 0.047). Moreover, the amount of energy derived from a healthy diet showed positive correlations with NPFT score (boys, β = 0.120, P = 0.011; girls, β = 0.137, P = 0.005).

Conclusions: Children's motor skills were associated with the Rohrer's index, involvement in sports lessons, outside playtime, and total energy intake, particularly that derived from a healthy diet. These results suggest that a well-balanced diet including grains, vegetables, fish and meat, fruits, and milk, is important for improving children's motor skills.

Background

Previous studies have found that cardiorespiratory endurance and muscular strength in childhood and adolescence are markers for systemic and abdominal fat, bone composition, and mental health [1]. Telama et al. reported that the group with the highest physical activity level and amount of physical activity between the ages of nine and 18 years also had high levels in adulthood [2], demonstrating that the amount of physical activity in childhood relates to future amounts of physical activity. Some studies have found links between the amount of physical activity, exercise habits, and morbidity of diseases such as ischemic heart disease [3], obesity [4], diabetes [5], and osteoporosis [6]. Childhood motor skills are important not only for the physical and mental health of children, but also for the prevention of future lifestyle diseases; thus, improving children's motor skills is vital. The Japanese government implements physical fitness and motor skills surveys to assess the current condition of Japanese citizens' physical fitness and motor skills. The New Physical Fitness Test (NPFT) is implemented annually to citizens including primary school children. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) aims to exceed the standard set results of 1985, which indicated a record high for children's physical fitness [7]. Physical Fitness Survey results up to fiscal year 2015 [7] indicate that children's abilities to run, jump, and throw are at a lower standard than they were in 1985, and that their abilities are not reaching target levels. Currently, the average height of first-grade primary school children is approximately 115 cm, with an average weight of approximately 21 kg. These measurements are largely the same as those among first-grade children in 1985 [8]. This reduction in motor skills despite consistent physique is concerning, as it could also lead to a lack of exercise and reduced motor skills in the future.

Previous studies have suggested a relationship between motor skills and lifestyle habits. One report indicates that adolescent children who eat breakfast every day have higher cardiorespiratory endurance than do children who skip breakfast [9]. Zaqout et al. [10] also demonstrated that gender, body mass index (BMI), psychological factors, consumption of fruit and vegetables, and amount of physical activity are determinants of a child's physical fitness.

Children in the growth phase must consume sufficient energy to support tissue synthesis and physical activity [11]. Previous studies have also reported that the content of food consumed by children is related to their physical and mental health. Emmett et al. demonstrated a link between increased body fat from childhood to adolescence and the consumption of energy-dense food [12]. Other reports have shown that children who eat breakfast have significantly higher academic performance, even after adjusting for confounding factors [13]; a significant positive correlation has also been shown between a high unhealthy food score (consumption of snacks, sweets, fizzy drinks, etc.) and depressed mood [14]. Mikkila et al. reported that a person's childhood diet is a significant determinant of their adult diet [15]; thus, it is important to form suitable dietary habits during childhood. However, most of these previous studies [9, 10, 13, 14] reported on the consumption frequency of fruits and vegetables, breakfast, or unhealthy foods, or evaluated the frequency of intake of limited food groups on a semi-quantitative basis. Although Mikkila et al. reported on the amount of energy and nutrition intake, they did not assess the physical fitness of children [15].

We hypothesized that children who receive more energy from healthy food groups have a higher physical fitness. To test this, the present study aimed to investigate how motor skills among first-grade children in Japan are associated with a healthy diet, after adjustment for lifestyle habits and various confounding factors.

Methods

A cross-sectional study of children and their guardians during the first year of compulsory education was conducted.

Participants

Self-administered questionnaires and dietary records of meals that children ate at home were distributed to 1,982 pairs of first-grade students aged 6-7 years and their guardians. Participating children were those who started school at three public primary schools in Tokyo between April 2013 and April 2018. Responses were obtained from 1,018 pairs (51.4%). Of these, 884 pairs (51.2 % boys and 48.8 % girls) were analysed after questionnaires with missing answers were excluded (Fig 1).

Data collection

The researcher responsible for the survey explained the aim and content of the survey to the principal, deputy principal, and class teachers in each school. The class teachers distributed envelopes containing consent forms, lifestyle habit questionnaires (to be filled out by the participants), and dietary records of meals that children ate at home to all first-grade children, except those in the special class for handicapped children. The survey forms were distributed annually between late May and early June, from 2013 to 2018, and were collected two weeks later. Consent forms and questionnaires were filled out at home, placed in an unsigned envelope, and sent to the researcher by each school.

Measures

Motor skills (New Physical Fitness Test score)

Each school measures eight items during the first term of every school year, based on the MEXT New Physical Fitness Test Implementation Guideline [16]. Included items are grip strength, sit-up exercises, sit and reach, side-step, 20-metre shuttle run, 50-metre run, standing long jump, and softball throw. Each measurement is allocated a score according to sex, in accordance with the Implementation Guideline. The total score for these eight items, or "NPFT score," was used for analysis of motor skills in the present study.

(1) Grip strength

Grip strength measurements were performed using a Smedley-type hand dynamometer. Children were positioned standing upright with feet placed a natural distance apart and arms by the sides of the body. They were then instructed to grip the hand dynamometer with all their strength to prevent the dynamometer from touching their body. The hand dynamometer was held tight to prevent it from swaying and the exercise was repeated twice on both the left and right sides. Scores were calculated as averages of the better results from each side. Boys were allocated the following point values: ≤ 4 kg = 1 point, 5–6 kg = 2 points, 7–8 kg = 3 points, 9–10 kg = 4 points, 11–13 kg = 5 points, 14–16 kg = 6 points, 17–19 kg = 7 points, 20–22 kg = 8 points, 23–25 kg = 9 points, and ≥ 26 kg = 10 points[16]. Girls were allocated the following point values: ≤ 3 kg = 1 point, 4–6 kg = 2 points, 7–8 kg = 3 points, 9–10 kg = 4 points, 11–12 kg = 5 points, 13–15 kg = 6 points, 16–18 kg = 7 points, 19–21 kg = 8 points, 22–24 kg = 9 points, and ≥ 25 kg = 10 points[16].

(2) Sit-up exercises

Sit-up exercises were performed with children lying on their backs, gripping both hands lightly with arms crossed in front of their chests, and knees bent at a 90° angle. An assistant was assigned to hold the children's knees. When given the signal to start, children were instructed to lift the upper body from a reclined position to an upright position until both elbows touched both thighs, and then to return to the starting position. This action was repeated as many times as possible in 30 seconds. This test was implemented once and the number of times the action was repeated within 30 seconds was recorded. Boys were allocated the following point values: ≤ 2 times = 1 point, 3–5 times = 2 points, 6–8 times = 3 points, 9–11 times = 4 points, 12–14 times = 5 points, 15–17 times = 6 points, 18–19 times = 7 points, 20–22 times = 8 points, 23–25 times = 9 points, and ≥ 26 times = 10 points[16]. Girls were allocated the following point values: ≤ 2 times = 1 point, 3–5 times = 2 points, 6–8 times = 3 points, 9–11 times = 4 points, 12–13 times = 5 points, 14–15 times = 6 points, 16–17 times = 7 points, 18–19 times = 8 points, 20–22 times = 9 points, and ≥ 23 times = 10 points [16].

(3) Sit and reach

Sit and reach measurements were performed using a stand made of two boxes approximately 25 cm in height that were joined across by a piece of cardboard across the top of both boxes. Children sat with both legs straight in front of them, between the two boxes, with their back and buttocks flush against a wall. They were instructed to place both hands flat on the nearest side of the cardboard, and to expand the chest with elbows straight to lengthen the spine. Children then bent forward from the starting position, without removing their hands, in order to slide the box as far forward as they could reach. The distance that the box was moved from the starting position was then measured with a ruler. This exercise was repeated twice, and the best result was recorded. Boys were allocated the following point values: ≤ 14 cm = 1 point, 15–18 cm = 2 points, 19–22 cm = 3 points, 23–26 cm = 4 points, 27–29 cm = 5 points, 30–33 cm = 6 points, 34–37 cm = 7 points, 38–42 cm = 8 points, 43–48 cm = 9 points, and ≥ 49 cm = 10 points[16]. Girls were allocated the following point values: ≤ 17 cm = 1 point, 18–20 cm = 2 points, 21–24 cm = 3 points, 25–28 cm = 4 points, 29–32 cm = 5 points, 33–36 cm = 6 points, 37–40 cm = 7 points, 41–45 cm = 8 points, 46–51 cm = 9 points, and ≥ 52 cm = 10 points [16].

(4) Side-step

A central line was drawn on the floor with two parallel lines drawn 100 cm to either side of the central line. Children were instructed to stand with their feet on either side of the central line and, when given the signal to start, to step sideways to straddle the right line, return to straddle the central line, and similarly step sideways to straddle the left line. The exercise was continued until children stepped either outside of or on the lines. Children repeated this exercise as many times as possible for 20 seconds, and the number of times any line was crossed was recorded. This test was repeated twice, and the best result was recorded. Boys were allocated the following point values: ≤ 17 times = 1 point, 18–21 times = 2 points, 22–25 times = 3 points, 26–29 times = 4 points, 30–33 times = 5 points, 34–37 times = 6 points, 38–41 times = 7 points, 42–45 times = 8 points, 46–49 times = 9 points, and ≥ 50 times = 10 points[16]. Girls were allocated the following point values: ≤ 16 times = 1 point, 17–20 times = 2 points, 21–24 times = 3 points, 25–27 times = 4 points, 28–31 times = 5 points, 32–35 times = 6 points, 36–39 times = 7 points, 40–42 times = 8 points, 43–46 times = 9 points, and ≥ 47 times = 10 points [16].

(5) 20-metre shuttle run

Children were instructed to run back and forth between two parallel lines placed 20 m apart in time with auditory prompts from a CD player. When prompts were played at fixed intervals, the children ran 20 m to the opposite line. When their feet touched or went past the line, they turned around to await the next prompt, and repeated the exercise. The intervals between auditory prompts were shortened approximately every minute, and children attempted to reach the opposite line before hearing the next prompt. The number of times that each child was able to run 20 m in time with the prompts was recorded as the total number of complete times. This exercise was performed once. Boys were allocated the following point values: ≤ 7 times = 1 point, 8–9 times = 2 points, 10–14 times = 3 points, 15–22 times = 4 points, 23–32 times = 5 points, 33–44 times = 6 points, 45–56 times = 7 points, 57–68 times = 8 points, 69–79 times = 9 points, and ≥ 80 times = 10 points[16]. Girls were allocated the following points: ≤ 7 times = 1 point, 8–9 times = 2 points, 10–13 times = 3 points, 14–18 times = 4 points, 19–25 times = 5 points, 26–34 times = 6 points, 35–43 times = 7 points, 44–53 times = 8 points, 54–63 times = 9 points, and ≥ 64 times = 10 points [16].

(6) 50-metre run

Children were instructed to run 50 m from a standing start. Times were recorded in 0.1-second units, with less than 0.1-second units rounded up. This exercise was performed once. Boys were allocated the following point values: ≥ 13.1 seconds = 1 point, 12.3–13.0 seconds = 2 points, 11.5–12.2 seconds = 3 points, 10.7–11.4 seconds = 4 points, 10.0–10.6 seconds = 5 points, 9.4–9.9 seconds = 6 points, 8.9–9.3 seconds = 7 points, 8.5–8.8 seconds = 8 points, 8.1–8.4 seconds = 9 points, and ≤ 8.0 seconds = 10 points[16]. Girls were allocated the following point values: ≥ 13.3 seconds = 1 point, 12.5–13.2 seconds = 2 points, 11.7–12.4 seconds = 3 points, 11.0–11.6 seconds = 4 points, 10.3–10.9 seconds = 5 points, 9.7–10.2 seconds = 6 points, 9.2–9.6 seconds = 7 points, 8.8–9.1 seconds = 8 points, 8.4–8.7 seconds = 9 points, and ≤ 8.3 seconds = 10 points [16].

(7) Standing long jump

Children were instructed to stand with feet slightly apart, and the tips of their toes aligned with the front edge of the take-off line. They then jumped with both feet in unison onto a sandpit or mat in front of the line. The landing position was measured based on the point closest to the take-off line and the distance between that point and the central point between both feet on the take-off line is measured in a straight line. This test was repeated twice, and the best result was recorded. Boys were allocated the following point values: ≤ 92 cm = 1 point, 93–104 cm = 2 points, 105–116 cm = 3 points, 117–129 cm = 4 points, 130–142 cm = 5 points, 143–155 cm = 6 points, 156–167 cm = 7 points, 168–179 cm = 8 points, 180–191 cm = 9 points, and ≥ 192 cm = 10 points [16]. Girls were allocated the following point values: ≤ 84 cm = 1 point, 85–97 cm = 2 points, 98–108 cm = 3 points, 109–120 cm = 4 points, 121–133 cm = 5 points, 134–146 cm = 6 points, 147–159 cm = 7 points, 160–169 cm = 8 points, 170–180 cm = 9 points, and ≥ 181 cm = 10 points [16].

(8) Softball throw

Children were instructed to throw a number one size softball (measuring 26.7 ± 0.32 cm in circumference). The distance to the location at which the ball landed within pre-drawn arcs at one-metre intervals was measured. This test was repeated twice, and the best result was recorded. Boys were allocated the following point values: ≤ 4 m = 1 point, 5–6 m = 2 points, 7–9 m = 3 points, 10–12 m = 4 points, 13–17 m = 5 points, 18–23 m = 6 points, 24–29 m = 7 points, 30–34 m = 8 points, 35–39 m = 9 points, and ≥ 40 m = 10 points[16]. Girls were allocated the following point values: ≤ 3 m = 1 point, 4 m = 2 points, 5 m = 3 points, 6–7 m = 4 points, 8–10 m = 5 points, 11–13 m = 6 points, 14–16 m = 7 points, 17–20 m = 8 points, 21–24 m = 9 points, and ≥ 25 m = 10 points [16].

Characteristics and lifestyle habits of children

Participating children were asked how frequently they played outside (every day, sometimes, or never). Guardians were asked to provide the following information about the children: height (cm); weight (kg); waking time; bedtime; frequency of eating breakfast per week (0–2, 3–4, 5–6, or 7 days); whether or not breakfast and dinner are eaten with an adult (parent, grandparent, and/or any other adult); participation in weekly lessons; time spent watching television per day; participation in video gaming or reading comics; time spent studying (minutes per day); and guardian's employment status (stay-at-home parent, part-time/casual work, or works five or more days per week). Weekly lessons were categorised into the following three groups, depending on lesson content: exercise (e.g., baseball, soccer, swimming, gymnastics, basketball, tennis, or ballet), music (e.g., violin, piano, orchestra, drums, or chorus), and classroom learning [e.g., painting, science, language, *juku* (cram school), calligraphy, abacus, or religious studies]. Lesson time per week was calculated based on the number of times each session was completed per week and the time spent at each session, as indicated by the guardian. A child's physique was calculated using the following Rohrer's index formula: weight (kg) / height (cm) ^{3} × 10^7.

Children's dietary habits

(1) Breakfast, dinner, and between-meal eating

Guardians of participating children provided information regarding the menu, ingredients, weight, and estimated dietary intake (including breakfast, lunch, dinner, and between-meal eating) of each child. This information was entered into the dietary record in as much detail as possible for an average school day.

(2) Lunch (school lunch)

Guardians of participating children entered information about meals eaten at home into the dietary record, but were unable to detail what the children ate during school lunches. In order to gather this information, 2–3 investigators were assigned to each class at each primary school to observe the children and survey their school lunch consumption.

Japanese school lunches are provided every day based on school lunch implementation standards [17] in accordance with Dietary Reference Intakes for Japanese [11] set forth by the Ministry of Health, Labour and Welfare, and these standards are followed with regard to the amount of energy, protein, lipid, sodium, calcium, iron, vitamins A, B1, B2, and C, and dietary fibre present in the lunches. Each school was surveyed for one day, and days with popular menus and thus higher eating rates than usual were avoided to ensure similar conditions across schools. Surveys were performed on days that white rice was served as the children's grain dish. Investigators were registered dieticians or students in the process of becoming registered dieticians. The amount of leftover food was recorded based on the amount of food in containers before serving, the amount of food left in containers after serving, and the amount of leftover food when the entire class finished eating their lunch. The intake of each individual child was ascertained in four stages for each dish, together with the number of second helpings for each child. Investigators observed children from the time they were served each dish up until the point they returned the trays. Consumption rate for each dish was evaluated using five categories (0% (food untouched), 25%, 50%, 75%, and 100% (completed)). Lunch intake per child was calculated using the following formulas and was considered to be the lunch intake for each individual child.

Amount of food for one class (a) = nutritional value of menu × number of children in the class

Amount of food supplied per person (b) = (a) × (1 − amount of class leftovers after finishing the first serving) ÷ number of children attending class on the survey date

Individual child intake = (b) × consumption rate + (a) × (amount of class leftovers after finishing the first serving − residual amount) ÷ total number of children who had second helpings × number of second helpings

(3) Nutritional value calculation

The energy content of surveyed meals was calculated using nutritional value calculation software (Excel Eiyo-kun, Version 8.0), with values based on the 2015 Standard Tables of Food Composition in Japan (Seventh Revised Version) [18]. Dietary intake was categorized by food group based on the Japanese Food Guide Spinning Top, which was formulated by the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Health, Labour and Welfare [18]. Food consumed by participating children was divided into six food groups, according to the criteria in the Japanese Food Guide Spinning Top, and numbers of servings were calculated. One serving (SV) was defined as the following: 40 g of carbohydrates for grain dishes; 70 g of the main ingredient in vegetable dishes; 6 g of protein in fish or meat dishes; 100 mg of calcium in milk or dairy products; 100 g of the main ingredient in fruit dishes; or 80 kcal of energy in snacks, confectionaries, or sweetened beverages. Children's intakes of breakfast, dinner, and between-meal eating were obtained from dietary records and combined with lunch intake to calculate daily intake.

(4) Breakdown of energy intake

Information on energy intake was examined in detail to assess the food content of children's diets. Energy intake from grain dishes, vegetable dishes, fish and meat dishes, milk and dairy products, and fruit was defined as the amount of energy derived from a healthy diet, based on food groups designated by the Japanese Food Guide Spinning Top [19]. Energy intake from snacks was defined as the amount of energy derived from snacks, confectionaries, and sweetened beverages. The combination of these two categories was defined as total energy intake. Confectionaries were classified according to the 2015 Standard Tables of Food Composition in Japan (Seventh Revised Version) [18]. Although the Standard Tables of Food Composition [18] classified ice cream as a dairy product, this study classified it as a confectionary. Similarly, this study categorized juice beverages that were not 100% fruit juice or that were from concentrate as sweetened beverages, in accordance with the Standard Tables of Food Composition [18] definition of sweetened beverages.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows (Version 23.0). A *P* value less than 0.05 was considered statistically significant. Participant characteristics were compared in relation to NPFT score quintile groups by gender with weighted one-way analyses of variance for continuous variables, and the Mantel–Haenszel test for trend for categorical variables.

A multiple regression analysis was conducted using the forced entry method for the investigation of items related to NPFT score quintile. In the multiple regression model, NPFT score was entered as an independent variable and the following were entered as dependent variables: Rohrer's index, sleep duration, frequency of outside playtime, time spent studying, time spent watching television, time spent video gaming or reading comics, participation in lessons (exercise, classroom learning, or music), frequency of eating breakfast per week, and total daily energy intake. When inputting the covariates, Rohrer's index was classified into eight quintiles and sleep duration was classified into eight categories with 30-minute increments. The frequency of outside playtime was set as '1' for responses of "almost every day (4–5 times a week)" for even one of the timeframes of morning, early break, lunch break, or after school; all other responses were assigned '0.' Study time was classified into eight categories with 15-minute increments. Total time spent watching television or participating in video gaming or reading comics was aggregated and classified into four categories with 60-minute increments. A value of '1' was allocated for children engaged in exercise, classroom learning, and/or music, whereas children not engaged in lessons were allocated dummy variables with a value of '0.' A value of '1' was allocated for frequency of eating breakfast per week responses of "7 times a week," whereas responses of "0–2," "3–4," or "5–6 times per week" were allocated dummy variables with a value of '0.'

Moderator variables for investigation of the relationship between NPFT score and daily energy intake included the following: Rohrer's index, sleep duration, frequency of outside playtime, time spent studying, time spent watching television, time spent video gaming or reading comics, participation in lessons (exercise, classroom learning, or music), and frequency of eating breakfast per week. Model 1 defined the explanatory variable as the amount of energy derived from a healthy diet. Model 2 defined the explanatory variable as the amount of energy derived from snacks. Model 3 defined the explanatory variable as the amount of energy derived from both a healthy diet and snacks.

This study complied with the Strengthening the Reporting of Observational Studies in Epidemiology – nutrition epidemiology (STROBE-nut) guidelines (see STROBE checklist, Additional file).

Results

In this study, 453 (51.2%) of the participating children were boys and 431 (48.8%) were girls. Boys had significantly higher values for height (P = 0.006) and weight (P = 0.001) than girls, but there was no significant difference in Rohrer's index (P = 0.303). There was a sex difference for all measurement items in the NPFT, except for sit-up exercises, and boys had significantly higher values in all items except for sit and reach (sit-up exercises, P=310; grip strength, P = 0.011; other items, P < 0.001). Overall NPFT scores were 30.0 ± 6.2 points for boys and 29.5 ± 6.2 points for girls, indicating no significant difference (P = 0.252). According to the dietary survey, boys had significantly higher energy

intake than girls for breakfast (boys, 370±128 kcal, girls, 336±117 kcal, P<0.001), lunch (boys, 501±134 kcal, girls, 470±128 kcal, P<0.001), dinner (boys, 577±187 kcal, girls, 527±175 kcal, P<0.001), between-meal eating (boys, 202±151 kcal, girls, 181±137 kcal, P=0.028), and from dairy products (boys, 1650±326 kcal, girls, 1515±289 kcal, P<0.001).

[Insert Table 1 here] Comparison of children's characteristics and lifestyle habits in the five NPFT score quintiles indicated that boys with higher NPFT scores had significantly higher heights (P < 0.001) and weights (P < 0.001). Boys also had significantly longer exercise lesson times (P < 0.001) and significantly higher frequencies of outside playtime (P < 0.001; Table 1). [Insert Table 2 here] Girls had significantly longer exercise lesson times (P = 0.010) and significantly lower Rohrer's index values (P = 0.039; Table 2). [Insert Table 3 here] Comparison of children's dietary intake in the five NPFT score quintiles indicated that boys with higher NPFT scores had significantly higher total energy intake at lunch (P < 0.003), total daily energy intake (P = 0.013), energy intake derived from a healthy diet (P = 0.003), vegetable dish intake (P = 0.001), and fish and meat dish intake (P = 0.028; Table 3). [Insert Table 4 here] Girls with higher NPFT scores had significantly higher values for total energy intake at breakfast (P = 0.008), energy intake derived from a healthy diet at breakfast (P = 0.030), total energy intake at lunch (P < 0.001), total daily energy intake (P = 0.001), energy intake derived from a healthy diet (P = 0.005), and fish and meat dish intake (P = 0.037; Table 4).

[Insert Table 5 here] The results of multiple regression analysis for investigation of factors related to NPFT scores are shown in Table 5. In boys, significant positive correlations were observed between frequency of outside playtime [standardised partial regression coefficient (β) = 0.135, P = 0.004], exercise lessons (β = 0.131, P = 0.006), and total daily energy intake (β = 0.096, P = 0.041). In girls, significant positive correlations were observed with exercise lessons (β = 0.121, P = 0.012), and total daily energy intake (β = 0.145, P = 0.003), while a significant negative correlation was observed with Rohrer's index (β = -0.097, P = 0.047). [Insert Table 6 here] Multiple regression analysis was also conducted to assess the relationships between NPFT scores and energy derived from a healthy diet and snacks. In boys, significant positive correlations were observed with energy intake derived from a healthy diet (β = 0.122, P = 0.009; Model 1). This relation was significant even after adjusting for snack intake (β = 0.120, P = 0.011; Model 3). Similarly, in girls, significant positive correlations were observed with energy intake derived from a healthy diet (β = 0.125, P = 0.010; Model 1). This relation was also significant even after adjusting for snack intake (β = 0.137, P = 0.005; Model 3). Snacks were not significantly correlated with NPFT score in boys or girls.

Discussion

Investigation of the factors related to motor skills in first-grade boys revealed significant positive correlations with the frequency of outside playtime, exercise lessons, and total daily energy intake. In girls, exercise lessons and total daily energy intake had positive correlations with NPFT score, while Rohrer's index had a significant negative correlation. Investigation of total energy intake revealed a significant positive correlation between dietary energy and motor skills in both boys and girls. Previous studies have reported that 13-year-old children who exercise three or more times per week have improved grip and 50-metre run results [7], and that moderate-to-vigorous physical activity (associated with ≥ 3 metabolic equivalents) by school-age and adolescent children is positively correlated with physical fitness [10, 20]. In this study, exercise lessons (one of the indices for daily physical activity) were positively correlated with NPFT scores, in keeping with previous research findings. Exercise lesson programmes such as baseball, soccer, and swimming often include basic skill practice in addition to competition. Thus, children attending exercise lessons regularly participate in activities such as side-stepping and sit-ups, as well as endurance enhancing exercises such as jogging. The strength developed during these activities is then displayed in NPFT exercises and may be positively correlated with NPFT scores. Reports have shown that children with three or more days per week of outside playtime (another index of daily physical activity) participate in significantly longer periods of light and total physical activity, as compared to children who do not play outside as frequently [21]. This study also found outside playtime to have a significant positive correlation with NPFT score in boys and, although the correlation was not significant among girls, a positive tendency was observed. Higher frequencies of outside playtime, corresponding to larger amounts of physical activity, affected NPFT scores.

A previous study reported a positive correlation between BMI and tests of physical fitness [10]. In contrast, this study found a significant negative correlation between NPFT score and Rohrer's index in girls and a tendency toward a negative correlation in boys. Comparison of Rohrer's index between the groups with the lowest and highest NPFT scores, however, showed that the mean values in all groups of both boys and girls were within the normal range for physique (Rohrer's index; 115 to < 145). Comparison of physical fitness measurements among children classified as thin, standard, or obese in the same previous study [10] indicated that children with standard body types had the best results. Therefore, it cannot be suggested that thinner children have higher NPFT scores.

This study did not observe significant correlations between NPFT scores and sleep duration or frequency of eating breakfast per week. Sandercock et al. [9] reported higher cardiorespiratory endurance values in adolescent children who ate breakfast every day, as compared to values among children who skipped breakfast. However, only 67.9% of the study subjects in the same study [9] ate breakfast every day, as compared to approximately 98% of subjects in the present study. The percentage of children who missed breakfast one or more days per

week in the current study was approximately 2%, which is a substantially smaller proportion than that observed previously. This difference may explain why the current study did not find breakfast consumption to be significantly correlated with NPFT scores. In the MEXT survey, children with eight or more hours of sleep per night had the highest NPFT scores [22]. However, no significant correlation between these elements was observed in the current study. Previous studies that did not indicate correlations between sleep duration and physical fitness found mean sleep durations to be 9.6–9.7 hours per night [10, 20]. The present study found the mean sleep duration to be 9.6 hours per night for both boys and girls, which supports the results of previous studies. Therefore, the lack of an observed correlation in this study may have been due to the children receiving adequate sleep. These findings suggest that not only physique and exercise habits, but also total daily energy intake, are correlated with motor skills in children.

Based on the results suggesting a correlation between NPFT score and total daily energy intake, further investigation of the total energy breakdown was performed. Energy intake derived from a healthy diet indicated a significant positive correlation, demonstrating that simply having a high daily energy intake was not correlated with NPFT score. Asghari et al. reported that higher consumption of confectionaries was associated with higher fat-energy ratios and lower protein-energy ratios [23]. The present study also found that fish and meat intake was positively correlated with NPFT scores in both boys and girls. The intake of confectionaries and sweetened beverages elevates blood sugar levels, with previous studies reporting that blood sugar levels peak within 30 minutes after consuming high-sugar foods before returning to fasting levels 60 minutes after eating [24]. In contrast to this rapid fluctuation, blood sugar gradually increases for up to 45 minutes after consuming non-sugar and medium-sugar foods, before steadily declining for up to 120 minutes after eating [24]. Previous studies have also reported higher grip and lower limb muscle strength in groups with higher protein intake [25] and positive correlations between physical fitness and frequency of fruit and vegetable consumption [10]. The consumption of energy from grains, vegetables, and fish and meat rather than from confectionaries and sweetened beverages promotes healthier children's bodies and provides the required energy and nutrients.

No significant correlations were observed with energy derived from snacks and NPFT scores. Comparison of the five NPFT quintiles in the present study showed a mean intake of approximately 200 kcal from confectionaries and sweetened beverages among both boys and girls in all groups (q1 to q5). Previous studies on the consumption of sweets by children have shown correlations with mental health problems [14] and lack of sleep [26]. Consumption of sweets and sweetened beverages by adults has also been correlated with psychological disorders [27]. Previous reports consisted of surveys on the frequency of consumption of sweets and sweetened beverages and, to our knowledge, there are no reports on these correlations with inclusion of specific quantities ingested. The Japanese Food Guide Spinning Top defines an adequate intake of sweets and sweetened beverages as ≤ 200 kcal [18]. Although the quantitative effect of sweets and sweetened beverages on humans is unknown, it is considered important to maintain an appropriate level of intake for these food groups. The results of this study suggest that it is important to consume sweets and sweetened beverages in moderation, and not to use these foods as a primary energy source. Energy should instead be consumed in the form of meals.

Strengths and limitations

The strength of this study was that it investigated the correlations between motor skills and nutritional intake among approximately 900 primary school students. The use of dietary records allowed for consideration of the mutual effects of meal quantity and quality, in addition to lifestyle habits. An additional strength was that multiple measurements of motor skills were performed in primary schools according to the MEXT guidelines.

This study had several limitations. First, the cross-sectional design prevented assessment of the potentially causative relationships between NPFT scores and lifestyle habits. In addition, the present study used a self-administered dietary record, which allowed for input of children's heights and weights based on the judgement of the guardian. Because food intake was only surveyed for one day, the meals consumed on that day may not be indicative of children's habitual meals. The dates on which dietary records were completed and the date of the school lunch survey were different; thus, the total intakes of breakfast, dinner, between-meal eating, and lunch were taken from different days. The combined results did not record all meals from a complete day, so caution is needed when interpreting the results. However, participating children and guardians were asked to enter data into the dietary record of meals that children ate at home that most closely represented meals on an average day, and school lunches were provided in accordance with Japanese school lunch implementation standards [17] and thus represent an average daily meal.

The present study was unable to obtain actigraphy or pedometer measurements as indices of physical activity, due to the significant burden this would place on participating teachers and children. These indices were instead set as the frequencies of outside playtime and exercise lessons. In addition, data on the guardians' educational backgrounds and household financial status could not be obtained. Future studies are needed to investigate the relationships between motor skills and actual measurements of the amount of physical activity among children, including various factors such as guardian educational background and household financial status. Finally, the response rate in this study was low at 44.6%, and many of the guardians were stay-at-home parents. The survey may thus have had a selection bias, with a

significant number of respondents who had a high degree of involvement in the survey and a high level of interest in participating children's meals and health.

Conclusions

The present study investigated the relationship between children's motor skills and their dietary and lifestyle habits. Study findings indicated that children's NPFT scores were significantly and positively correlated with involvement in sports lessons, total energy intake, and outside playtime in boys, and negatively correlated with Rohrer's index in girls. Further investigation of daily energy intake breakdown revealed a correlation between NPFT scores and daily energy intake derived from a healthy diet, independent of children's physique or exercise habits.

These results demonstrated that children's physique and exercise habits, in addition to consumption of a healthy diet that includes grains, vegetables, fruits, milk, fish and meat, are important for children's motor skills. It is essential that dietary education be conducted to encourage the intake of a healthy diet, and to investigate whether this leads to improvements in motor skills.

List Of Abbreviations

NPFT: New Physical Fitness Test

MEXT: Ministry of Education, Culture, Sports, Science and Technology

BMI: body mass index

STROBE-nut: Strengthening the Reporting of Observational Studies in Epidemiology – nutrition epidemiology

Declarations

Ethics approval and consent to participate: This study was conducted according to the guidelines outlined in the Declaration of Helsinki. All procedures involving research study participants were approved by the Human Research Ethics Committees at Tokyo University of Agriculture (Reference numbers: 1122, 1130, 1501, 1605, 1704, 1802). Written informed consent was obtained from all subjects.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated and analysed during the current study are not publicly available, but some data are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: YT, TF, AH, and YK designed the research; YT, NH, MK, RK, and TH conducted the research; YT and NH analyzed the data; YT and NH wrote the manuscript; YT assumes primary responsibility for the final content. All authors read and approved the final manuscript.

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Tables

1. Characteristics and lifestyle habits within New Physical Fitness Test score quintile groups among boys

		NPFT score quintile					
		q1 (n=88)	q2 (n=67)	q3 (n=93)	q4 (n=106)	q5 (n=99)	
dian		22.0	26.0	29.0	32.0	38.0	P for trend
Max)		(13.0 - 24.0)	(25.0 - 27.0)	(28.0 - 30.0)	(31.0 - 34.0)	(35.0 - 49.0)	
ıt	(cm)	116.3 ± 5.7	117.8 ± 5.5	117.6 ± 5.1	118.8 ± 4.7	119.3 ± 4.8	< 0.001
ht	(m)	20.3 ± 2.7	20.7 ± 2.5	21.1 ± 3.1	21.6 ± 3.2	21.5 ± 2.6	< 0.001
er's	(kg/m^3)	129.3 ± 15.0	127.1 ± 13.4	129.6 ± 13.0	128.5 ± 11.5	126.8 ± 12.9	0.335
gth	(kg)	6.7 ± 1.9	7.8 ± 1.8	8.2 ± 1.7	8.7 ± 1.9	9.8 ± 2.1	< 0.001
ises	(times)	7.0 ± 4.8	9.8 ± 4.6	11.5 ± 4.5	12.7 ± 3.1	15.6 ± 4.6	< 0.001
ıd	(cm)	22.1 ± 5.1	23.9 ± 6.4	24.6 ± 6.0	26.2 ± 5.6	29.0 ± 5.5	< 0.001
step	(points)	23.2 ± 4.6	24.1 ± 5.4	26.1 ± 4.7	28.2 ± 4.1	31.6 ± 3.9	< 0.001
etre e run	(times)	11.9 ± 4.2	17.2 ± 7.7	17.7 ± 7.1	22.6 ± 11.1	28.6 ± 13.8	< 0.001
etre	(sec)	12.3 ± 0.9	11.8 ± 0.7	11.5 ± 0.6	10.9 ± 0.6	10.6 ± 0.5	< 0.001
ling ump	(cm)	97.5 ± 13.5	104.4 ± 12.8	110.0 ± 13.7	115.3 ± 11.3	127.3 ± 11.7	< 0.001
all	(m)	5.8 ± 2.2	6.1 ± 2.1	7.7 ± 2.5	7.9 ± 2.7	10.5 ± 3.5	< 0.001
ion	(hours/day)	9.5 ± 0.6	9.6 ± 0.7	9.5 ± 0.6	9.8 ± 0.7	9.6 ± 0.7	0.278
ing	(min/day)	49.1 ± 23.7	44.3 ± 19.1	42.7 ± 21.3	47.4 ± 44.7	44.6 ± 21.8	0.529
ning sion	(min/day)	78.5 ± 61.3	74.5 ± 46.4	83.8 ± 46.2	70.2 ± 41.0	75.3 ± 42.9	0.442
ng s/ ng es	(min/day)	20.2 ± 25.3	23.2 ± 40.9	28.1 ± 31.0	17.2 ± 24.1	23.3 ± 23.2	0.973
on cise)	(min/week)	81.8 ± 118.2	104.2 ± 107.7	114.1 ± 126.6	155.7 ± 143.9	195.7 ± 167.9	< 0.001
on sroom ing)	(min/week)	62.7 ± 72.5	61.3 ± 79.8	45.3 ± 80.1	47.7 ± 65.9	47.9 ± 59.7	0.079
on c)	(min/week)	9.0 ± 24.2	9.6 ± 21.8	8.6 ± 20.8	5.9 ± 21.0	6.8 ± 17.4	0.258
uency side me	Always	74 (84.1)	61 (91.0)	87 (93.5)	102 (96.2)	95 (96.0)	< 0.001
uency ing fast	0-2 times/week	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.866
	3-4 times/week	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.0)	
	5-6 times/week	2 (2.3)	1 (1.5)	2 (2.2)	1 (0.9)	1 (1.0)	
	7 times/week	86 (97.7)	66 (98.5)	91 (97.8)	105 (99.1)	97 (98.0)	

±SD or number (%)

ues are based on weighted one-way analysis of variance for continuous variables, or the Mantel-Haenszel test for trend for categorical variables.

', New Physical Fitness Test

2. Characteristics and lifestyle habits within New Physical Fitness Test score quintile groups among girls

		NPFT score quintile				
		q1 (n=70)	q2 (n=96)	q3 (n=82)	q4 (n=91)	q5 (n=92)
dian		21.0	26.0	29.0	33.0	38.0
Max)		(9.0 - 23.0)	(24.0 - 27.0)	(28.0 - 30.0)	(31.0 - 34.0)	(35.0 - 46.0)
ıt	(cm)	114.2 ± 5.5	115.1 ± 5.4	117.5 ± 4.6	117.7 ± 4.4	118.5 ± 4.7
ht	(m)	19.5 ± 2.9	20.0 ± 3.0	20.9 ± 3.1	20.9 ± 2.9	21.3 ± 2.9
er's	(kg/m^3)	131.0 ± 13.8	131.2 ± 14.5	128.2 ± 13.4	127.8 ± 12.1	128.0 ± 13.0
gth	(kg)	6.3 ± 2.1	7.4 ± 1.6	7.7 ± 1.5	8.4 ± 2.0	9.6 ± 2.1
ises	(times)	6.5 ± 5.1	10.0 ± 5.1	11.1 ± 4.2	12.4 ± 4.2	14.9 ± 3.6
ıd	(cm)	22.9 ± 6.4	27.0 ± 6.2	28.5 ± 5.3	30.0 ± 6.5	32.8 ± 6.5
step	(points)	22.2 ± 6.5	24.0 ± 4.8	25.7 ± 3.9	27.1 ± 3.3	28.3 ± 3.9
etre e run	(times)	11.0 ± 5.2	14.4 ± 6.6	15.6 ± 6.7	18.7 ± 8.1	23.4 ± 9.4
etre	(sec)	12.7 ± 1.9	12.1 ± 0.7	11.6 ± 0.6	11.3 ± 0.7	10.8 ± 0.5
ling ump	(cm)	90.7 ± 20.9	99.5 ± 13.3	103.8 ± 11.5	108.2 ± 12.6	118.4 ± 11.5
all	(m)	3.9 ± 1.5	4.4 ± 1.5	5.2 ± 1.6	5.8 ± 1.6	6.4 ± 1.9
ion	(hours/day)	9.5 ± 0.7	9.7 ± 0.6	9.5 ± 0.6	9.6 ± 0.5	9.6 ± 0.7
ing	(min/day)	41.9 ± 19.9	48.9 ± 25.0	46.9 ± 34.3	41.2 ± 17.4	44.8 ± 32.7
ning sion	(min/day)	64.3 ± 41.6	74.2 ± 45.0	72.5 ± 48.2	66.8 ± 42.9	66.0 ± 49.2
ng s/ ng es	(min/day)	15.0 ± 25.4	14.8 ± 27.5	15.3 ± 28.7	12.9 ± 20.8	12.4 ± 23.2
on cise)	(min/week)	54.3 ± 61.1	73.4 ± 84.6	93.9 ± 106.3	82.3 ± 90.1	96.1 ± 131.4
on sroom ing)	(min/week)	47.0 ± 78.8	59.3 ± 77.6	61.2 ± 66.4	56.7 ± 91.1	39.5 ± 60.1
on c)	(min/week)	16.1 ± 30.2	22.5 ± 38.6	24.8 ± 32.7	27.9 ± 36.5	23.2 ± 35.9
uency side me	Always	60 (85.7)	83 (86.5)	73 (89.0)	86 (94.5)	84 (91.3)
uency ing fast	0-2 times/week	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	3-4 times/week	1 (1.4)	1 (1.0)	1 (1.2)	0 (0)	0 (0.0)
	5-6 times/week	0 (0.0)	3 (3.1)	3 (3.7)	3 (3.3)	1 (1.1)
	7 times/week	69 (98.6)	92 (95.8)	78 (95.1)	88 (96.7)	91 (98.9)

±SD or number (%)

ues are based on weighted one-way analysis of variance for continuous variables, or the Mantel-Haenszel test for trend for categorical variables.

', New Physical Fitness Test

Table 3. Dietary intake within New Physical Fitness Test score quintile groups among boys

		NPFT score quintile					P for trend
		q1 (n=88)	q2 (n=67)	q3 (n=93)	q4 (n=106)	q5 (n=99)	
Breakfast							
Total energy	(kcal)	355 ± 114	383 ± 123	362 ± 129	377 ± 146	374 ± 122	0.387
Energy derived from a healthy diet[1]	(kcal)	321 ± 125	352 ± 133	323 ± 122	334 ± 138	332 ± 134	0.819
Energy derived from snacks	(kcal)	35 ± 81	31 ± 61	39 ± 81	43 ± 97	42 ± 107	0.362
Lunch							
Total energy	(kcal)	478 ± 137	476 ± 117	490 ± 135	516 ± 137	531 ± 134	0.003
Dinner							
Total energy	(kcal)	538 ± 169	627 ± 214	562 ± 195	560 ± 178	609 ± 178	0.152
Energy derived from a healthy diet[1]	(kcal)	530 ± 168	611 ± 205	551 ± 194	552 ± 176	597 ± 177	0.153
Energy derived from snacks	(kcal)	7 ± 11	17 ± 34	11 ± 18	8 ± 14	12 ± 19	0.815
Between meal eating							
Total energy	(kcal)	208 ± 159	178 ± 129	213 ± 165	210 ± 143	194 ± 152	0.951
Energy derived from a healthy diet[1]	(kcal)	52 ± 96	40 ± 70	41 ± 80	70 ± 93	66 ± 125	0.071
Energy derived from snacks	(kcal)	156 ± 138	138 ± 121	172 ± 132	140 ± 128	128 ± 117	0.151
Daily							
Total energy	(kcal)	1579 ± 321	1665 ± 306	1628 ± 369	1663 ± 307	1708 ± 315	0.013
Energy derived from a healthy diet[1]	(kcal)	1381 ± 274	1479 ± 282	1406 ± 319	1472 ± 294	1526 ± 319	0.003
Energy derived from snacks	(kcal)	198 ± 177	185 ± 140	222 ± 161	191 ± 156	182 ± 170	0.548
Grain dishes	(SV)	2.90 ± 0.85	2.87 ± 0.76	2.83 ± 0.76	2.99 ± 0.85	3.11 ± 1.06	0.055
Vegetable dishes	(SV)	3.39 ± 1.38	3.89 ± 1.62	3.62 ± 1.70	4.12 ± 2.08	4.25 ± 1.91	0.001
Fish and meat dishes	(SV)	4.42 ± 1.79	5.16 ± 2.03	4.66 ± 1.86	4.89 ± 2.01	5.22 ± 2.11	0.028
Milk and dairy products	(SV)	3.67 ± 1.41	4.06 ± 2.23	3.72 ± 1.92	3.96 ± 1.81	3.84 ± 2.06	0.643
Fruits	(SV)	0.70 ± 0.78	0.86 ± 0.92	0.78 ± 0.85	0.87 ± 0.98	0.78 ± 0.71	0.485
Snacks, confectionaries, and sweetened beverages	(SV)	2.58 ± 2.24	2.44 ± 1.75	2.87 ± 2.01	2.50 ± 1.94	2.39 ± 2.12	0.554

NPFT, New Physical Fitness Test

[1]Energy intake derived from grain dishes, vegetable dishes, fish and meat dishes, milk and dairy products, and fruit (based on the food groups defined by the Japanese Food Guide Spinning Top), as opposed to snacks, confectionaries, and sweetened beverages

Mean ± SD

Table 4. Dietary intake within New Physical Fitness Test score quintile groups among girls

		NPFT score quintile					P for trend
		q1(n=70)	q2(n=96)	q3(n=82)	q4(n=91)	q5(n=92)	
Breakfast							
Total energy	(kcal)	317 ± 119	323 ± 125	328 ± 107	353 ± 124	355 ± 105	0.008
Energy derived from a healthy diet[1]	(kcal)	289 ± 133	286 ± 123	294 ± 125	333 ± 129	311 ± 118	0.030
Energy derived from snacks	(kcal)	28 ± 63	37 ± 75	34 ± 67	20 ± 41	44 ± 91	0.606
Lunch							
Total energy	(kcal)	417 ± 126	480 ± 127	448 ± 110	470 ± 115	520 ± 138	<0.001
Dinner							
Total energy	(kcal)	538 ± 148	524 ± 158	502 ± 163	536 ± 221	535 ± 172	0.848
Energy derived from a healthy diet[1]	(kcal)	527 ± 144	515 ± 155	492 ± 156	524 ± 219	524 ± 170	0.875
Energy derived from snacks	(kcal)	10 ± 18	10 ± 13	10 ± 18	13 ± 25	10 ± 13	0.515
Between meal eating							
Total energy	(kcal)	166 ± 126	190 ± 148	178 ± 157	194 ± 137	173 ± 114	0.780
Energy derived from a healthy diet[1]	(kcal)	37 ± 65	52 ± 98	52 ± 109	44 ± 74	31 ± 62	0.375
Energy derived from snacks	(kcal)	129 ± 110	138 ± 124	126 ± 125	150 ± 123	142 ± 104	0.338
Daily							
Total energy	(kcal)	1438 ± 270	1517 ± 278	1457 ± 278	1554 ± 329	1583 ± 262	0.001
Energy derived from a healthy diet[1]	(kcal)	1271 ± 265	1333 ± 275	1287 ± 264	1372 ± 310	1387 ± 251	0.005
Energy derived from snacks	(kcal)	167 ± 127	184 ± 140	170 ± 142	184 ± 142	196 ± 149	0.254
Grain dishes	(SV)	2.65 ± 0.78	2.72 ± 0.77	2.69 ± 0.75	2.72 ± 0.75	2.86 ± 0.79	0.111
Vegetable dishes	(SV)	3.63 ± 1.48	3.92 ± 1.59	3.61 ± 1.63	3.85 ± 1.60	4.13 ± 1.65	0.101
Fish and meat dishes	(SV)	4.06 ± 1.52	4.28 ± 1.65	4.37 ± 2.11	4.66 ± 1.99	4.54 ± 1.69	0.037
Milk and dairy products	(SV)	3.34 ± 1.52	3.53 ± 1.67	2.89 ± 1.51	3.61 ± 1.64	3.37 ± 1.60	0.805
Fruits	(SV)	0.74 ± 0.79	0.61 ± 0.79	0.77 ± 0.80	0.87 ± 0.93	0.70 ± 0.89	0.516
Snacks, confectionaries, and sweetened beverages	(SV)	2.17 ± 1.59	2.40 ± 1.74	2.21 ± 1.76	2.39 ± 1.77	2.56 ± 1.85	0.207

NPFT, New Physical Fitness Test

[1]Energy intake derived from grain dishes, vegetable dishes, fish and meat dishes, milk and dairy products, and fruit (based on the food groups defined by the Japanese Food Guide Spinning Top), as opposed to snacks, confectionaries, and sweetened beverages
Mean ± SD

Table 5. Multiple regression analysis to investigate factors related to New Physical Fitness Test score

	Boys		Girls	
	β*	P	β*	P
Rohrer's index	-0.091	0.055	-0.097	0.047
Sleep duration	0.021	0.661	0.019	0.695
Frequency of outside play time	0.135	0.004	0.088	0.066
Studying	-0.069	0.147	-0.046	0.341
Watching TV/ playing video games/ reading comics	0.036	0.454	0.0001	0.998
Lesson (exercise)	0.131	0.006	0.121	0.012
Lesson (classroom learning)	-0.014	0.768	-0.029	0.557

Lesson (music)	-0.014	0.771	0.063	0.200
Frequency of eating breakfast	0.014	0.757	0.002	0.969
Daily total energy	0.096	0.041	0.145	0.003

* Standardized regression coefficient

Rohrer's index was classified into eight quintiles. Sleep duration was classified into eight categories with 30-minute increments. The frequency of outside playtime was set as '1' for responses of "almost every day (4–5 times a week)" for even one of the timeframes of morning, early break, lunch break or after school; all other responses were set as dummy variables with a value of '0.' Study time was classified into eight categories with 15-minute increments. The total time spent watching television or participating in video gaming or reading comics was aggregated and classified into four categories with 60-minute increments. A value of '1' was allocated for children engaged in exercise, classroom learning, and/or music, whereas children not engaged in lessons were allocated dummy variables with a value of '0.' A value of '1' was allocated for frequency of eating breakfast per week responses of "7 times a week," whereas responses of "0–2," "3–4," or "5–6 times per week" were allocated dummy variables with a value of '0.'

Table 6. Multiple regression analysis for New Physical Fitness Test score and energy derived from healthy diet/snacks

		Boys		Girls	
		β†	P	β†	P
Model 1	Energy derived from a healthy diet‡	0.122	0.009	0.125	0.010
Model 2	Energy derived from snacks	-0.032	0.494	0.056	0.245
Model 3	Energy derived from a healthy diet‡	0.120	0.011	0.137	0.005
	Energy derived from snacks	-0.019	0.682	0.077	0.113

Each model was adjusted for Rohrer's index, sleep duration, the frequency of outside playtime, study time, the total time spent watching television or participating in video gaming or reading comics, participation in lessons (exercise, classroom learning, and/or music), and the frequency of eating breakfast per week.

†Standardized regression coefficient

‡Energy intake derived from grain dishes, vegetable dishes, fish and meat dishes, milk and dairy products, and fruit (based on the food groups defined by the Japanese Food Guide Spinning Top), as opposed to snacks, confectionaries, and sweetened beverages

Figures

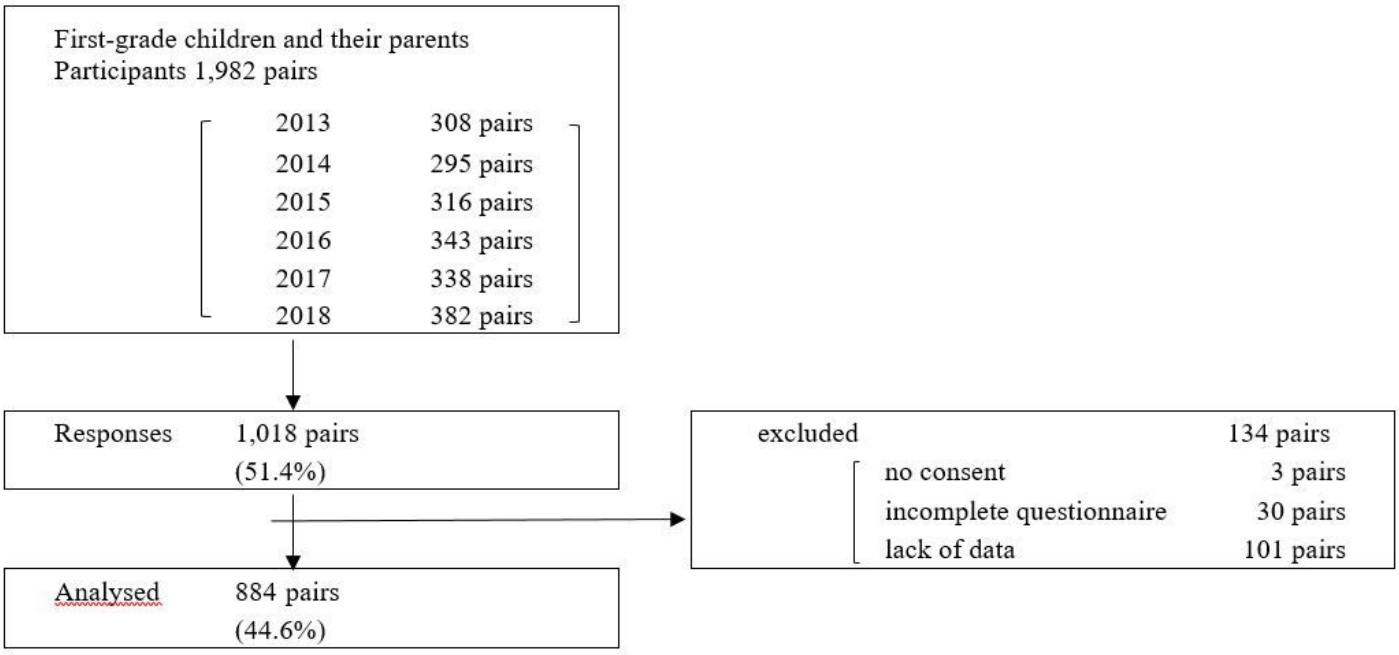

Figure 1

Flowchart of participant selection

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- MotorskillsandlifestyleinchildrenRevisedSTROBENut.docx