SFA intake among Japanese schoolchildren: current status and possible intervention to prevent excess intake

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Abstract

Objective: Although a high intake of fat, particularly SFA, is a well-known risk factor for CVD, fat intake in Japan has attracted relatively little attention from health professionals to date due to the low intake in the Japanese population. However, recent surveys have shown an increase in fat intake in younger Japanese populations. Here, we described the fat intake and dietary sources of SFA in Japanese schoolchildren. Also, we experimentally exchanged a high-SFA food with a low-SFA substitute in the data, and calculated the resulting changes in nutrient intakes.

Design: The study was conducted nationwide under a cross-sectional design. A non-consecutive, three-day diet record was performed on two school days and a non-school day.

Setting: Fourteen elementary and thirteen junior high schools.

Subjects: Elementary-school children (*n* 629) and junior high-school children (*n* 281).

Results: Prevalence of excess fat intake was 35·4 % in boys and 45·0 % in girls. Excess SFA intake was suspected in 97·7 % of boys and 99·4 % of girls when the dietary reference intake values for adults were applied. Major dietary sources of SFA were meat (26·4 % of total SFA intake), dairy products (25·7 %) and confectioneries (11·3 %).

Conclusions: Since one-third to nearly one-half of our Japanese schoolchildren consumed excess fat, careful monitoring of fat intake in the Japanese population should be continued. Adoption of low-fat milk and/or lean meat in daily meals might be a suitable means of reducing fat, particularly SFA intake, in schoolchildren.

Keywords
Fat
SFA
Japanese schoolchildren
Virtual intervention

Higher intake of SFA has been associated with higher serum total and LDL cholesterol concentrations[1–3] and higher risk of CVD[4,5]. SFA are not essential fatty acids and minimization of intake as low as possible is preferable for good health[6,7]. Since extreme restriction of SFA intake can cause insufficiencies in other nutrients such as protein or essential fatty acids, however, dietary recommendations or guidelines in several countries set maximum SFA intake at around 10 % of energy (E %). However, SFA intake in most Western countries is higher than the recommended values in both adults and children[6,8,9].

Fat intake in Japan has so far attracted relatively little attention from health professionals. The fat content of traditional Japanese dishes is generally low, and the mean fat intake in the Japanese population of 26·3 E % in 2014[10] is within the range (20–30 E %) of 'the tentative dietary goal for preventing life-style related diseases (DG)' for total fat in the Dietary Reference Intakes (DRI) for Japanese, 2015[11]. With regard to SFA, the DG has been set at ≤7 E % for adults, but no reference value has been set for children due to a lack of SFA intake data[11]. Nevertheless, the National Health and Nutrition Survey in Japan showed that fat intake in young generations was much higher than that in older people in Japan. The proportion of adults whose fat intake in 2014 was more than 30 E % was 49·7 % in people in their 20s, but only 15·8 % in those in their 70s or older[10]. With traditional diets changing to more Westernized diets, fat intake among the Japanese population may continue to increase with time. In addition, heart disease has become the second-leading cause of death in Japan, with mortality of 156·5 per 100 000 individuals in 2015[12]. Given reports that dietary habits established in childhood track into later life[13], this increasing fat intake in younger Japanese warrants careful observation.

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We had the opportunity to conduct a nationwide dietary assessment among Japanese schoolchildren[14]. Here, we utilized these data to describe fat intake and dietary sources of SFA in Japanese elementary-school and junior high-school children in detail. In addition, we experimentally exchanged a high-SFA food with a low-SFA substitute (e.g. full-fat milk to low-fat milk) in the data, and calculated the resulting changes in nutrient intakes.

Methods

Study participants

Details of the study design and participant characteristics have been reported elsewhere[14]. Briefly, twelve prefectures (Aomori, Yamagata, Ibaraki, Tochigi, Toyama, Shiga, Shimane, Ehime, Kochi, Fukuoka, Saga and Kagoshima) were chosen as study areas in consideration of geographical conditions (e.g. north or south, rural or urban) and study feasibility. From each area, ninety children (thirty children in each of third and fifth grade of elementary school and thirty children in second grade of junior high school) on average were recruited by teachers in the schools. All children in classes selected for the survey received a written document to explain the survey and recording sheets for the diet record. Finally, a total of 1190 children (389 third and 392 fifth graders from fourteen elementary schools and 409 second graders from thirteen junior high schools) were recruited.

Semi-weighed diet record

In the present study, dietary intake of the subjects was assessed by diet record (DR) at home and school, and their weight and height were measured at school[14]. Each school set the period for the non-consecutive, three-day DR and conducted the measurement of height and weight within one month of that period. All records were collected by the study centre at the university of the researchers and checked by the researchers. The dietitians or teachers who managed the survey at each school had a correspondence table which linked the children's names and identification numbers for the survey, but the researchers did not have access to this information.

Details of the semi-weighed DR have been provided elsewhere[14]. Briefly, guardians of the participating children were asked to complete a three-day, non-consecutive DR of their children's dietary intake, of whom 915 complied (participation rate: 76·9 %). The three recording days for the DR consisted of two school days with a school lunch and one weekend day without a school lunch, all within the same week (e.g. Tuesday, Thursday and Saturday within one week).

Dietary intake from the school lunch was weighed and recorded by the school dietitian or the child under the dietitian's support. Dietary intake at home was recorded by the guardian who was the main preparer of meals for the participating child. All foods and beverages consumed out of school were recorded on the same two days set for the school lunch survey as well as on the one weekend (non-school) day. The guardians weighed the ingredients in dishes, the prepared dishes after cooking and all drinks, whenever possible. Leftover food was also weighed after the meal to estimate the net weight of consumed foods. If subjects ate out and weighing was difficult, they recorded the restaurant's name, names of dishes and whether any food was left uneaten.

The recording sheets for each survey day were handed directly to the school dietitian immediately after recording, then checked by the school dietitian as soon as possible. If missing or unclear information was recorded by a subject, the research dietitian questioned the subject directly. After this confirmation process, food item numbers[15] were assigned to all recorded foods and beverages. Recorded food items and weights were then reconfirmed by two research dietitians at the central office of the study. The weight of each food and ingredient included in the school lunch was estimated at the office based on the weight of consumed dishes and conversion charts prepared by the school dietitians. The data for the lunch and the other meals were combined, and the nutrient values were calculated. All calculations were performed with the statistical software package SAS version 9·4.

Other measurements

Body height and weight were measured to the nearest 0·1 cm and 0·1 kg, respectively, with the child wearing light clothing and no shoes. The prevalence of obesity in the children was evaluated by percentage of excess weight, which was defined using the formula: [(actual weight − standard weight)/standard weight] × 100 (%). If percentage of excess weight was ≥20 %, the child was categorized as overweight, and if ≤−20 %, he/she was categorized as underweight. The standard weight was calculated using age- and sex-specific formulas which included actual height and coefficients[16].

Statistical analysis

Among the 915 children who completed the three-day DR, 910 were included in the analysis. Five children were eliminated from the analysis due to severe under-reporting[14]. To compare the fat intakes reported in the DR and the corresponding DRI values[11], we adjusted the reported fat intakes to the energy-adjusted intakes on the assumption that each subject consumed his/her estimated energy requirement (EER) rather than his/her reported energy[14]. The calculation method was as follows: Energy-adjusted nutrient intake (amount/d) = [reported nutrient intake (amount/d) × EER (kcal/d)]/[observed energy intake (kcal/d)]. The EER for each child was calculated based on sex and age in days. Physical activity level was

fixed to level II (moderate)[11] in all participating children due to the absence of quantitative information about physical activity. Utilizing these energy-adjusted fat intakes of three days, we estimated the distribution of habitual intake of total fat and each fatty acid in this population by the best-power method using HabitDist, a software application developed to perform this method[17–19]. The medians and interquartile ranges were described separately by sex and grade. For total fat and SFA, the percentage of energy (E%), i.e. the percentage of energy intake from total fat or SFA to total energy intake, was used for comparison with DRI values. The Japanese DRI give DG for total fat in children, but not for SFA[11]. We therefore tentatively applied the DG for SFA in adults to children[11]. Energy-adjusted intake levels outside the range of the corresponding DG were considered inadequate. For nutrients with an Adequate Intake, the prevalence of inadequacy was not calculated.

Next, the contributions of food groups as dietary SFA sources were explored. The definition of the food groups has been described elsewhere[20]. The contribution of each food group was calculated as follows: {[SFA intake (g) from each food group]/[daily total SFA intake (g)]} × 100 (%). The means of percentages were shown separately by sex and grade, and those less than 1% were not shown.

Lastly, we experimentally exchanged a high-SFA food with a low-SFA substitute in the DR data, and estimated the resulting changes in nutrient intakes. The performed exchanges were:

1a. full-fat milk containing 3·8% fat to low-fat milk containing 1·0% fat (food item numbers[15] in the DR data: 13 001–13 003 were replaced with 13 005);
1b. full-fat and low-fat milk to skimmed milk containing 0·1% fat (food item numbers 13 001–13 003 and 13 005 replaced with 13 006);
2. meat with fat (i.e. fatty meat including subcutaneous, intermuscular and intramuscular fat) to lean meat (e.g. food item numbers 11 004 and 11 005 (beef chuck with all fat or subcutaneous fat, raw) replaced with 11 006 (beef chuck, lean, raw)); and
3. deletion of confectioneries (food item numbers in the 15 000s consumed as 'snacks' were deleted from the DR data).

The nutritional value calculation was performed using SAS version 9·4 as described above. No energy adjustment was performed for this analysis because the intakes were compared within each subject. Energy, protein, total fat, SFA and PUFA intakes were described for all selected foods before and after the replacement by sex and grade separately. Other nutrients were chosen based on the dominance of contents in the foods and the prevalence of insufficiency among schoolchildren as clarified in a previous study[14]. Vitamin A and Ca for milk, thiamin and Fe for meat, and carbohydrate and salt for confectioneries were selected. Mean intakes before and after replacement

were compared with the Wilcoxon signed-rank test. The prevalence of inadequacy was calculated for SFA intake by comparing the mean intake (E%) with the DG value for SFA intake in adults (≤7 E%). The mean intake used here differed from the habitual intake estimated by the best-power method, and the distribution of the mean SFA intake was broader than that of the habitual intake. All analyses were performed using SAS version 9·4. Statistical tests were two-sided and P values of <0·05 were considered statistically significant.

Results

Subject characteristics are shown in Table 1. Each grade and sex stratum included approximately 150 children. Energy-adjusted, habitual fat intake is described in Table 2. The prevalence of inadequacy for total fat intake was 35·4% in all boys and 45·0% in all girls. All instances of 'inadequacy' were 'excess intake' for total fat. Although the Japanese DRI do not provide reference values for SFA for children, we tentatively compared the SFA intake in children with the reference value (DG) for adults. The SFA intake of 97·7% of the boys and 99·4% of the girls was higher than the DG (≤7 E%).

Major dietary sources of SFA are listed in Table 3. The three major sources were meat (26·4% of total SFA intake came from meats in all children), dairy products (25·7%) and confectioneries (11·3%). The contribution of dairy products and confectioneries to SFA intake was smaller in children in higher grades. Instead, the importance of meat as an SFA source increased with age, particularly in boys. The contribution of fish and shellfish was also larger in children in higher grades.

Estimated nutrient intakes before and after the replacement of SFA-rich foods in the data are shown in Table 4. When full-fat milk was exchanged with low-fat milk, medians of SFA intake decreased from more than 9 E% (9·0–9·6) to 7·7–8·2 E%. This decrease was largest in the third graders. Protein and Ca intakes increased by this replacement, but vitamin A intake decreased. The prevalence of inadequacy was changed by the replacement from 53·0% to 45·4% for Ca and from 27·5% to 38·2% for vitamin A in the total population. If skimmed milk was used instead of full-fat milk, SFA intake decreased more (7·4–7·8 E%) but Ca and vitamin A intakes decreased. The prevalence of inadequacy was increased by this replacement from 53·0% to 57·6% for Ca and from 27·5% to 46·5% for vitamin A. The replacement of meat with fat with lean meat also decreased SFA intake to 7·9–8·8 E%. The decrease in SFA intake by meat replacement was smaller than that of milk, particularly in elementary-school children, whereas the effects of these foods were similar in junior high-school children. The meat replacement also increased protein and Fe intakes. Deletion of confectioneries as snacks also decreased SFA intake but the decrease was smaller than

Table 1 Characteristics schoolchildren (n 910) from fourteen elementary and thirteen junior high schools in twelve prefectures of Japan, 2014

		Boys						Girls					
		Elementary school				Junior high school		Elementary school				Junior high school	
		3rd grade (n 154)		5th grade (n 144)		2nd grade (n 134)		3rd grade (n 155)		5th grade (n 176)		2nd grade (n 147)	
Variable	Category	n or mean	% or SD	n or mean	% or SD	n or mean	% or SD	n or mean	% or SD	n or mean	% or SD	n or mean	% or SD
Age (years)	8	54	35·1	0	0·0	0	0·0	49	31·8	0	0·0	0	0·0
	9	100	64·9	0	0·0	0	0·0	106	68·8	0	0·0	0	0·0
	10	0	0·0	42	27·3	0	0·0	0	0·0	72	46·8	0	0·0
	11	0	0·0	102	66·2	0	0·0	0	0·0	104	67·5	0	0·0
	13	0	0·0	0	0·0	34	22·1	0	0·0	0	0·0	53	34·4
	14	0	0·0	0	0·0	100	64·9	0	0·0	0	0·0	94	61·0
Height (cm)	Mean, SD	131·6	5·6	143·1	6·6	163·7	7·4	131·0	5·0	144·0	6·7	156·3	5·0
Weight (kg)	Mean, SD	29·7	6·3	37·6	8·6	54·8	11·6	28·8	5·7	37·5	8·1	48·9	7·7
Body constitution†	Underweight	3	2·0	4	2·8	2	1·5	2	1·3	4	2·3	8	5·4
	Normal	134	87·0	121	84·0	115	85·8	133	85·8	153	86·9	131	89·1
	Overweight	17	11·0	19	13·2	17	12·7	20	12·9	19	10·8	8	5·4
Energy intake (kJ/d)	Mean, SD	8075	1234	9092	1460	11 360	2360	7740	1197	8301	1314	9096	1724
Energy intake (kcal/d)	Mean, SD	1930	295	2173	349	2715	564	1850	286	1984	314	2174	412

Data are presented as n and % unless indicated otherwise.
†Body constitution was evaluated by percentage of excess weight, defined using the following formula: [(actual weight − standard weight)/standard weight] × 100 (%). If percentage of excess weight was ≥20 %, the child was categorized as overweight, and if ≤−20 %, he/she was categorized as underweight.

those with the other replacements. Salt intake also decreased slightly with this replacement. Almost all intakes were statistically significantly different before and after replacement, but carbohydrate intake was not significantly changed by the deletion of confectioneries in boys. The prevalence of inadequacy for SFA intake is also shown in Table 4; although prevalence was lower than that calculated using the habitual intake shown in Table 3, owing to the broader distribution of the mean intake, the decrease in inadequate intake after replacement was obvious.

Discussion

One-third to nearly one-half of these Japanese schoolchildren consumed excess fat, and SFA intake in almost all of them was greater than the DG value (≤7 E %) for Japanese adults. Major dietary sources of SFA were meat, dairy products and confectioneries. Adoption of low-fat milk and/or lean meat in daily meals would likely be a suitable means of reducing fat, particularly SFA intake in schoolchildren. Cessation of snack intake might also reduce SFA intake, albeit that the effect was not so large.

Fat intake in Japanese adults and children has been increasing steadily[10,21,22]. According to the National Health and Nutrition Survey in Japan, mean fat intake in 2003 was 23·1 E % in adult men and 24·9 E % in women, but increased to 25·5 E % and 27·2 E %, respectively, in 2015[23]. The increase was not as apparent among children (28·4 E % in 2003 to 29·8 E % in 2015 in boys aged 7–14 years, 29·0 E % to 29·2 E % in the same period in girls of the same age) compared with adults, but their absolute intakes

of both total fat and SFA were considerably higher than those for adults[10]. SFA intake in the Japanese population has been reported in the National Health and Nutrition Survey since 2011. The median SFA intake in 2014 was 19·1 g/d in boys aged 7–14 years, 17·8 g/d in girls, 14·2 g/d in adult men and 12·2 g/d in women[10]. The change in SFA intake was not clear due to the short period of observation. Higher intake of dairy products among children was reported in the National Health and Nutrition Survey (median intake: 256·0 g/d in children aged 7–14 years, 50·0 g/d in adults aged ≥20 years), which may be a major reason for the higher fat intake among children[10]. Intake of confectioneries was also higher in children (median intake: 20·0 g/d in children in the same age range, 0·0 g/d in adults)[10]. Given the increasing meat intake and decreasing fish intake among the Japanese population[10], SFA intake could increase in the future and careful attention should be paid to it, particularly for children whose SFA intake is already higher than that of adults.

Several studies have reported serum cholesterol levels in Japanese. For adults, one study reported no significant change over the last 10 years[10], whereas another study reported a slight increase in serum total cholesterol from 1990 to 2000[24]. Among children, no trend was seen in serum total, HDL and non-HDL cholesterol from 1993 to 2008[25]. Fat intake in Japan is still lower than in Western countries[8,9] and this absolute low intake may be the reason for the non-significant change in serum lipids. On the other hand, mortality from heart disease has been increasing (157 deaths per 100 000 population per year in 2015) to become the second-leading cause of death in Japan[12]. Although this mortality is lower than

Table 2 Energy-adjusted, habitual fat intake†, and comparison with Dietary Reference Intakes for Japanese 2015, in Japanese schoolchildren (*n* 910) from fourteen elementary and thirteen junior high schools in twelve prefectures of Japan, 2014

			Elementary school, 3rd grade (8–9 years; 154 boys, 155 girls)				Elementary school, 5th grade (10–11 years; 144 boys, 176 girls)				Junior high school, 2nd grade (13–14 years; 134 boys, 147 girls)			
			Intake				Intake				Intake			
Sex	Habitual intake	Unit	Median	IQR	Ref. value	Prevalence (%) of inadequacy‡	Median	IQR	Ref. value	Prevalence (%) of inadequacy‡	Median	IQR	Ref. value	Prevalence (%) of inadequacy‡
Boys	Fat, total	g/d	60·9	56·9–63·8	–	–	74·3	70·1–78·4	–	–	83·6	77·9–90·3	–	–
	Fat, total	E%	29·1	27·4–30·3	20–30 (DG)	30·5 (30·5)	29·6	27·8–30·9	20–30 (DG)	42·4 (42·4)	28·3	26·3–30·5	20–30 (DG)	31·3 (30·6)
	SFA	g/d	19·9	18·1–21·8	–	–	23·5	21·8–25·3	–	–	26·6	23·7–29·3	–	–
	SFA	E%	9·5	8·7–10·2	≤7 (DG)§	(100·0)	9·3	8·6–10·0	≤7 (DG)§	(97·9)	9·0	8·0–9·9	≤7 (DG)§	(94·0)
	MUFA	g/d	20·4	19·2–22·2	–	–	25·5	23·4–27·6	–	–	29·5	27·1–32·3	–	–
	PUFA	g/d	11·4	10·6–11·9	–	–	13·9	13·2–14·6	–	–	15·8	14·4–17·4	–	–
	n-6 PUFA	g/d	9·7	9·0–10·2	9 (AI)	–	11·9	11·3–12·7	9 (AI)	–	13·3	12·0–14·7	12 (AI)	–
	n-3 PUFA	g/d	1·7	1·6–1·8	1·7 (AI)	–	2·0	1·9–2·2	1·7 (AI)	–	2·5	2·3–2·8	2·1 (AI)	–
Girls	Fat, total	g/d	57·6	53·6–61·6	–	–	69·4	63·9–74·7	–	–	78·9	74·1–82·8	–	–
	Fat, total	E%	29·9	27·8–31·9	20–30 (DG)	47·7 (47·7)	29·7	27·5–31·6	20–30 (DG)	41·5 (41·5)	29·8	28·0–31·4	20–30 (DG)	44·9 (44·9)
	SFA	g/d	18·6	17·2–20·5	–	–	21·9	20·7–24·1	–	–	24·9	23·5–26·3	–	–
	SFA	E%	9·7	8·9–10·6	≤7 (DG)§	(99·4)	9·4	8·8–10·2	≤7 (DG)§	(99·4)	9·4	8·9–10·0	≤7 (DG)§	(100·0)
	MUFA	g/d	19·4	17·9–21·2	–	–	23·9	21·7–26·0	–	–	27·4	25·7–29·3	–	–
	PUFA	g/d	10·7	9·7–11·4	–	–	12·7	11·7–14·0	–	–	14·7	13·6–15·8	–	–
	n-6 PUFA	g/d	9·1	8·3–9·7	7 (AI)	–	10·8	9·9–12·0	8 (AI)	–	12·4	11·3–13·4	10 (AI)	–
	n-3 PUFA	g/d	1·6	1·5–1·8	1·4 (AI)	–	2·0	1·8–2·3	1·5 (AI)	–	2·3	2·2–2·5	1·8 (AI)	–

IQR, interquartile range; ref. value, reference value; E%, percentage of energy; DG, the tentative dietary goal for preventing life-style related diseases; AI, Adequate Intake; EER, estimated energy requirement.
All intakes shown here were estimated habitual intakes. Habitual intake was calculated by the best-power method using a three-day diet record.
†Nutrient intake of each day was energy-adjusted based on the assumption that every subject consumed the same amount of energy as his/her EER.
‡Prevalence of inadequacy is the percentage of children whose energy-adjusted habitual nutrient intake level was outside the range of the corresponding dietary reference intake value. The percentage of subjects whose intake was above the reference range is shown in parentheses.
§Reference value for people aged over 18 years.

Table 3 Contribution of food groups as SFA sources in Japanese schoolchildren (*n* 910) from fourteen elementary and thirteen junior high schools in twelve prefectures of Japan, 2014

Sex	Dietary source of SFA (food group)	Elementary school, 3rd grade (8–9 years; 154 boys, 155 girls) Mean	SD	Elementary school, 5th grade (10–11 years; 144 boys, 176 girls) Mean	SD	Junior high school, 2nd grade (13–14 years; 134 boys, 147 girls) Mean	SD
Boys	Well-milled rice	1·7	0·7	1·8	0·9	2·2	1·1
	Bread	1·8	1·8	2·2	1·9	1·8	1·7
	Noodles	2·3	4·8	1·6	3·7	2·0	4·0
	Pulses	3·3	2·6	3·3	2·6	2·9	2·5
	Fish and shellfish	3·6	3·7	3·4	3·7	4·5	4·4
	Meat	23·5	11·1	27·3	10·2	30·3	12·9
	Eggs	6·0	3·9	5·9	3·7	5·3	3·6
	Dairy products	27·3	10·4	25·9	9·8	24·1	10·8
	Fats	3·8	4·3	3·9	4·4	4·4	5·2
	Oils	6·7	4·3	7·6	4·2	8·3	5·7
	Confectioneries	13·0	10·5	10·5	8·9	8·8	9·1
	Seasonings	3·3	3·3	3·0	3·6	1·9	2·7
	Ready-made foods	1·3	2·3	1·4	2·5	1·1	2·1
Girls	Well-milled rice	1·6	0·9	1·7	0·9	1·9	0·9
	Bread	1·9	1·7	2·2	2·2	2·1	2·3
	Noodles	1·6	3·1	1·7	3·6	1·6	3·3
	Pulses	3·1	2·2	3·0	2·5	3·3	2·2
	Fish and shellfish	3·6	4·0	4·0	4·8	4·2	4·3
	Meat	24·2	11·5	25·1	10·5	28·5	11·7
	Eggs	6·4	3·9	6·4	3·5	6·1	4·0
	Dairy products	26·8	8·7	25·4	10·4	24·3	9·3
	Fats	4·0	5·2	4·8	5·8	5·3	5·8
	Oils	7·3	4·2	7·7	5·4	7·8	6·0
	Confectioneries	13·5	10·1	11·6	9·7	10·1	10·0
	Seasonings	2·6	2·8	2·8	3·2	1·7	2·3
	Ready-made foods	1·3	3·1	1·3	2·9	0·6	1·8

†Contribution (%) of each food group as a source of SFA to total SFA intake is shown, calculated as: {[SFA intake (g) from each food group]/[daily total SFA intake (g)]} × 100. Only mean contributions greater than 1 % are shown.

that in other countries (e.g. 167 deaths per 100 000 population per year in the USA in 2014[26]; 383·4 deaths (circulatory disease) and 132 deaths (IHD only) per 100 000 population per year in the EU in 2013[27]), careful monitoring of fat intake is important even in Japan to avoid further increases in CVD as a result of excess fat intake.

Since children need additional energy for growth, energy expenditure per kilogram of body weight is higher than in adults[7,11]. In particular, the energy cost of growth in infants is high (10–30 % of total energy requirement in those aged <6 months)[28] and several dietary guidelines recommend higher fat intake for young children (<1 to <3 years of age)[6,7,11]. Regarding school-aged children, most guidelines recommend almost the same total fat and SFA as those for adults, and reported total fat and SFA intakes in E% among school-aged children are in fact the same as in adults in many countries[8,9]. However, it seems that evidence to decide the optimum level of SFA intake specific for school-aged children is lacking worldwide, because, strictly speaking, cohort studies with a long follow-up period are needed to show the relationship between SFA intake in childhood and health outcomes in adulthood. Nupponen *et al.* reported that dietary counselling in childhood to reduce SFA intake was effective in prevention of metabolic syndrome in adolescence[29], but they did not describe the absolute intake of SFA. In accordance with the fact that a number of dietary recommendations apply the recommended SFA intake for adults to children, we applied the DG for SFA in Japanese adults to children. Since dietary habits established in childhood track into later life[13], this application may be the best way to define the recommendation for children at this time. On the other hand, Butte reported that lower fat intake (<30 E%) may be associated with inadequate vitamin and mineral intakes and increase the risk of poor growth in children, and that the current recommendation of 30 E% from dietary fat for children aged >2 years is sufficient for adequate growth[28].

Based on our present results, the current status of fat intake in Japanese children is clearly better (i.e. lower) than that of children in many other developed countries. However, the percentage of energy from fat is higher in younger generations, particularly so in Japanese children[10]. Given that the trend of increasing total fat and SFA intakes might continue, it may be necessary to discuss whether SFA intake in children should even be restricted in Japan.

Table 4 Change in fat and other nutrient intakes† after replacing a food which is a major source of SFA with a lower-fat food in Japanese schoolchildren (*n* 910) from fourteen elementary and thirteen junior high schools in twelve prefectures of Japan, 2014

Sex	Replacement	Energy or nutrient	Unit	Elementary school, 3rd grade (8–9 years; 154 boys, 155 girls) Before replacement Median	IQR	After replacement Median	IQR	Diff.	Elementary school, 5th grade (10–11 years; 144 boys, 176 girls) Before replacement Median	IQR	After replacement Median	IQR	Diff.	Junior high school, 2nd grade (13–14 years; 134 boys, 147 girls) Before replacement Median	IQR	After replacement Median	IQR	Diff.
Boys	Full-fat milk → low-fat milk	Energy	kJ/d	8075	7163–8904	7866	6996–8657	*	8895	8142–10 063	8728	7975–9740	*	11 288	9623–12 577	11 067	9427–12 226	*
		Energy	kcal/d	1930	1712–2128	1880	1672–2069	*	2126	1946–2405	2086	1906–2328	*	2698	2300–3006	2645	2253–2922	*
		Protein	E%	14·6	13·3–15·6	15·1	13·9–16·2	*	14·7	13·7–15·4	15·1	14·2–16·1	*	14·1	12·7–15·0	14·7	13·1–15·5	*
		Fat, total	E%	29·2	26·3–31·3	27·0	23·9–29·5	*	29·5	26·7–31·8	27·4	24·7–29·6	*	28·1	25·5–31·1	26·4	23·5–29·5	*
		SFA	E%	9·4	8·3–10·8	7·9	6·9–9·1	*	9·2	8·3–10·3	8·0	7·2–8·9	*	9·0	7·6–10·3	7·7	6·5–9·0	*
		PUFA	g/d	11·5	9·2–13·5	11·2	9·0–13·4	*	12·9	11·0–15·7	12·7	10·8–15·6	*	15·4	12·7–19·8	15·2	12·5–19·7	*
		Vitamin A	µg RAE/d	470	374–589	415	329–527	*	536	438–649	477	390–592	*	553	449–716	501	401–654	*
		Ca	mg/d	603	506–731	634	543–772	*	641	532–776	681	566–835	*	700	601–878	736	645–926	*
		Prev. inadeq. for SFA‡	%	94·8		72·7			95·1		78·5			86·6		66·4		
	Full-fat milk → skimmed milk	Energy	kJ/d	same as above		7745	6832–8514	*	same as above		8644	7849–9676	*	same as above		10 878	9347–12 004	*
		Energy	kcal/d	"		1851	1633–2035	*	"		2066	1876–2313	*	"		2600	2234–2869	*
		Protein	E%	"		15·1	14·0–16·3	*	"		15·2	14·2–16·2	*	"		14·7	13·2–15·6	*
		Fat, total	E%	"		26·3	23·3–29·0	*	"		27·0	24·1–29·2	*	"		26·0	23·0–29·1	*
		SFA	E%	"		7·4	6·4–8·5	*	"		7·6	6·7–8·3	*	"		7·4	6·1–8·6	*
		PUFA	g/d	"		11·1	8·9–13·4	*	"		12·6	10·7–15·5	*	"		15·1	12·4–19·6	*
		Vitamin A	µg RAE/d	"		383	298–499	*	"		449	360–560	*	"		478	380–608	*
		Ca	mg/d	"		586	486–701	*	"		622	518–756	*	"		685	585–839	*
		Prev. inadeq for SFA‡	%	94·8		60·4			95·1		68·8			86·6		55·2		
	Meat with fat → lean meat	Energy	kJ/d	same as above		7895	7042–8606	*	same as above		8611	7937–9778	*	same as above		10 870	9343–12 434	*
		Energy	kcal/d	"		1887	1683–2057	*	"		2058	1897–2337	*	"		2598	2233–2950	*
		Protein	E%	"		15·1	14·0–16·4	*	"		15·5	14·4–16·3	*	"		14·8	13·5–16·0	*
		Fat, total	E%	"		26·8	24·4–29·4	*	"		26·6	24·2–29·4	*	"		25·2	22·6–29·0	*
		SFA	E%	"		8·6	7·5–9·8	*	"		8·3	7·2–9·4	*	"		7·9	6·7–9·1	*
		PUFA	g/d	"		10·8	8·8–12·8	*	"		12·2	10·1–14·7	*	"		14·5	11·9–18·6	*
		Thiamin	mg/d	1·0	0·8–1·2	1·0	0·8–1·2	*	1·1	1·0–1·4	1·2	1·0–1·4	*	1·3	1·1–1·6	1·4	1·1–1·7	*
		Fe	mg/d	6·8	5·9–7·7	7·1	6·0–8·0	*	7·6	6·6–8·7	8·0	6·9–9·1	*	8·6	7·5–9·9	9·0	7·8–10·6	*
		Prev. inadeq. for SFA‡	%	94·8		87·7			95·1		81·9			86·6		68·7		
	Confectioneries → delete	Energy	kJ/d	same as above		7627	6786–8351	*	same as above		8544	7803–9523	*	same as above		10 715	9218–11 765	*
		Energy	kcal/d	"		1823	1622–1996	*	"		2042	1865–2276	*	"		2561	2203–2812	*
		Protein	E%	"		15·1	13·9–16·0	*	"		15·0	14·1–15·9	*	"		14·6	13·1–15·5	*
		Fat, total	E%	"		28·5	25·2–30·9	*	"		28·8	26·4–31·6	*	"		27·8	24·9–31·3	*
		SFA	E%	"		8·9	8·1–10·4	*	"		9·1	8·1–10·1	*	"		8·8	7·4–9·9	*
		PUFA	g/d	"		10·3	8·8–12·7	*	"		12·2	10·3–15·1	*	"		14·8	11·9–18·0	*
		Carbohydrate	E%	55·3	52·2–58·7	55·3	52·2–58·7		54·6	51·9–57·7	54·6	51·8–57·6		56·1	52·1–59·1	56·0	51·7–59·2	
		Salt	g/d	9·1	7·3–10·6	8·9	7·1–10·4	*	9·9	8·2–11·5	9·6	8·1–11·4	*	11·0	9·6–13·0	10·8	9·4–12·6	*
		Prev. inadeq. for SFA‡	%	94·8		92·9			95·1		93·8			86·6		82·8		

Table 4 *Continued*

Sex	Replacement	Energy or nutrient	Unit	Elementary school, 3rd grade (8–9 years; 154 boys, 155 girls) Before replacement Median	IQR	After replacement Median	IQR	Diff.	Elementary school, 5th grade (10–11 years; 144 boys, 176 girls) Before replacement Median	IQR	After replacement Median	IQR	Diff.	Junior high school, 2nd grade (13–14 years; 134 boys, 147 girls) Before replacement Median	IQR	After replacement Median	IQR	Diff.
Girls	Full-fat milk → low-fat milk	Energy	kJ/d	7745	6832–8517	7552	6690–8318	*	8234	7431–9096	8017	7293–8929	*	8858	7983–10146	8686	7845–9996	*
		Energy	kcal/d	1851	1633–2036	1805	1599–1988	*	1968	1776–2174	1916	1743–2134	*	2117	1908–2425	2076	1875–2389	*
		Protein	E%	14.5	13.2–15.7	15.0	13.7–16.4	*	14.4	13.5–15.7	15.0	13.9–16.4	*	14.7	13.6–15.7	15.3	14.1–16.3	*
		Fat, total	E%	29.9	26.7–33.0	27.7	24.8–30.8	*	29.7	26.5–32.6	27.2	24.7–30.5	*	29.9	26.6–32.8	28.2	24.6–31.3	*
		SFA	E%	9.6	8.5–11.1	8.1	7.3–9.6	*	9.3	8.4–10.6	8.1	7.2–9.1	*	9.3	8.4–10.6	8.2	7.0–9.3	*
		PUFA	g/d	10.9	9.2–13.3	10.8	9.1–13.0	*	12.0	9.6–14.0	11.6	9.5–13.9	*	12.8	10.9–16.0	12.5	10.7–15.8	*
		Vitamin A	µg RAE/d	469	384–590	428	335–535	*	511	425–626	455	380–570	*	571	418–733	521	375–680	*
		Ca	mg/d	574	494–682	602	523–719	*	598	512–707	635	540–754	*	628	524–751	669	555–787	*
		Prev. inadeq. for SFA‡	%	92.9		80.0			93.2		80.1			91.8		75.5		
	Full-fat milk → skimmed milk	Energy	kJ/d	same as above		7414	6577–8171	*	same as above		7904	7196–8824	*	same as above		8502	7761–9878	*
		Energy	kcal/d	"		1772	1572–1953	*	"		1889	1720–2109	*	"		2032	1855–2361	*
		Protein	E%	"		15.0	13.8–16.5	*	"		15.0	13.9–16.4	*	"		15.3	14.1–16.4	*
		Fat, total	E%	"		27.2	24.3–30.2	*	"		26.5	24.1–30.1	*	"		27.9	24.2–31.0	*
		SFA	E%	"		7.6	6.8–9.1	*	"		7.6	6.7–8.7	*	"		7.8	6.5–8.9	*
		PUFA	g/d	"		10.7	9.0–13.0	*	"		11.6	9.4–13.9	*	"		12.5	10.7–15.8	*
		Vitamin A	µg RAE/d	"		404	306–504	*	"		433	353–551	*	"		492	354–643	*
		Ca	mg/d	"		556	479–649	*	"		578	498–681	*	"		608	507–731	*
		Prev. inadeq. for SFA‡	%	92.9		66.5			93.2		63.6			91.8		66.0		
	Meat with fat → lean meat	Energy	kJ/d	same as above		7510	6703–8314	*	same as above		8000	7234–8828	*	same as above		8590	7728–9791	*
		Energy	kcal/d	"		1795	1602–1987	*	"		1912	1729–2110	*	"		2053	1847–2340	*
		Protein	E%	"		15.0	13.9–16.5	*	"		15.2	14.2–16.5	*	"		15.6	14.3–16.8	*
		Fat, total	E%	"		28.1	24.8–30.9	*	"		27.6	24.6–30.1	*	"		27.0	23.9–29.6	*
		SFA	E%	"		8.8	7.7–10.4	*	"		8.5	7.7–9.6	*	"		8.4	7.1–9.5	*
		PUFA	g/d	"		10.5	8.7–12.7	*	"		11.2	9.2–13.5	*	"		12.0	10.1–15.0	*
		Thiamin	mg/d	0.9	0.8–1.1	0.9	0.8–1.1	*	1.0	0.9–1.1	1.0	0.9–1.2	*	1.0	0.9–1.3	1.1	1.0–1.4	*
		Fe	mg/d	6.7	5.8–7.9	6.9	6.0–8.1	*	7.2	6.2–8.2	7.3	6.4–8.4	*	7.8	6.5–9.0	8.1	6.8–9.2	&
		Prev. inadeq. for SFA‡	%	92.9		88.4			93.2		88.1			91.8		77.6		
	Confectioneries → delete	Energy	kJ/d	same as above		7201	6477–7912	*	same as above		7891	7117–8514	*	same as above		8502	7682–9514	*
		Energy	kcal/d	"		1721	1548–1891	*	"		1886	1701–2035	*	"		2032	1836–2274	*
		Protein	E%	"		15.2	14.0–16.3	*	"		15.0	13.9–16.2	*	"		15.0	14.1–16.0	*
		Fat, total	E%	"		29.4	26.8–32.8	*	"		29.1	25.9–31.9	*	"		29.4	25.7–32.2	*
		SFA	E%	"		9.4	8.2–10.6	*	"		9.1	8.0–103	*	"		9.1	7.9–10.2	*
		PUFA	g/d	"		10.6	8.5–12.3	*	"		11.2	9.2–13.6	*	"		12.5	10.2–15.0	*
		Carbohydrate	E%	54.0	51.1–58.1	53.8	50.8–57.7	*	54.8	51.3–57.9	54.7	51.2–58.1		53.8	51.0–57.6	54.3	51.1–58.1	*
		Salt	g/d	8.4	7.1–10.0	8.2	7.0–9.6	*	9.3	7.7–10.5	9.1	7.7–10.3	*	9.5	8.1–11.1	9.4	7.9–10.9	*
		Prev. inadeq. for SFA‡	%	92.9		91.6			93.2		89.2			91.8		88.4		

IQR, interquartile range; diff., significance of the difference in energy and nutrient intakes between before and after the replacement; prev. inadeq., prevalence of inadequacy; E%, percentage of energy; RAE, retinol activity equivalents.
*$P < 0.05$ (significant difference, Wilcoxon signed-rank test).
†Mean energy and nutrient intakes in three days are shown without energy adjustment.
‡Prevalence of inadequacy for SFA is the percentage of children whose mean SFA intake level was outside the range of the dietary reference intake value for SFA in adults (≤7 E%).

We previously reported that the major dietary problem of Japanese schoolchildren was the intake of excess salt, excess fat and low dietary fibre[14]. Regarding fat, intakes of meat, dairy products and confectioneries are good targets for intervention to reduce fat, particularly SFA intake. These foods have also been reported as major dietary sources of SFA and cholesterol in other countries[6,7]. For example, Rehm et al. reported that substituting skimmed or low-fat milk for whole, reduced-fat and flavoured milk reduced the percentage of energy from SFA by 2·5 E % and 1·4 E %, respectively, in the USA[30]. In Japan, whole milk is provided in school lunches. Inadequacy of Ca intake was much lower on a school day than on a non-school day (34·0 % v. 74·3 % in boys, 31·6 % v. 78·2 % in girls) as reported in our previous study[14], and this is a beneficial effect of milk in school lunches. However, it may be necessary to discuss the fat content in milk to reduce SFA intake among Japanese children. The substitution of meat with fat may be more complex, but was attempted in the Dietary Intervention Study in Children (DISC) study[31]. In the present study, cessation of confectionery intake was not so effective in reducing fat, particularly SFA intake; intake was low, at approximately 20 g/4184 kJ (1000 kcal), and a number of children did not have the habit of snacking (data not shown). Thus, cessation of snacking can only be useful in those who habitually consume confectioneries. In Japanese children, the contribution of dairy products as a source of SFA decreased with age, whereas that of meat increased with age, suggesting that age-specific interventions may be effective in reducing fat intake. Sex differences were less obvious than those of age, but the contribution of meat as an SFA source was slightly larger in boys and that of confectioneries was larger in girls.

The present study has several strengths, which reflect those in our previous paper[14]. The study was school-based and nationwide, with a relatively high participation rate (76·9 %). The study areas were chosen from various prefectures of different characteristics and the selected schools were public ones without special food or health education. The generalizability of the results is considered to be sufficient. Additional strengths were its quantitative assessment of dietary intake and use of a three-day DR, which allowed us to estimate the habitual intake and dietary sources of each nutrient in the analysed population.

At the same time, several limitations also warrant mention. First, since most analyses were performed with stratification by sex and age, the number of children in each stratum was approximately 150. Although this might appear small for estimation of average intakes and exact distributions, results across strata were similar, and could be interpreted. Second, a three-day DR might be too short to allow habitual intake to be estimated with precision. However, given the heavy burden of DR assessment on participants, a period longer than 3 d was not considered feasible. Third, as nutrient content is not uniform even in the same kind of food (e.g. full-fat milk or meat with fat), changes in fat and nutrient intakes before and after food replacement may be inconstant. We used representative nutrition contents in the food composition table[15] and these must have provided the best estimations compared with other simulation methods.

Conclusions

Since one-third to nearly one-half of our Japanese schoolchildren consumed excess fat and SFA intake in almost all of them was greater than the DG value (≤7 E %) for Japanese adults, careful monitoring of fat intake in the Japanese population should be continued. The major dietary sources of SFA were meat, dairy products and confectioneries. Adoption of low-fat milk and/or lean meat in daily meals might be a suitable means of reducing the intake of fat, particularly SFA, in Japanese schoolchildren.

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