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Snacking in Japanese nursery school children aged 3–6 years: its characteristics and contribution to overall dietary intake

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Abstract

Objective: This cross-sectional study evaluated the dietary characteristics of snacks, the contribution of snacks to daily nutrient intake and the association of energy intake (EI) from snacks with the prevalence of nutritional inadequacy in Japanese nursery school children.
Design: Foods and nutrients consumed in each eating occasion were assessed by 3-d dietary records. The prevalence of inadequate intake of twenty nutrients assessed by the age- and sex-specific reference values in the Japanese Dietary Reference Intakes was compared according to tertile categories of EI from snacks.
Setting: A multi-regional dietary survey based on nursery schools in Japan.
Participants A total of 187 boys and 191 girls aged 3–6 years.
Results: EI from snacks accounted for 19·5 % (SD 6·9) of total daily EI. Confectionaries accounted for the largest part of EI from snacks (35·3 %), followed by milk (19·5 %). Relative to their energy contribution, snacks accounted for a small proportion for all nutrients examined, except for free sugar, calcium, SFA and riboflavin. Although a higher EI from snacks was associated with favourable profiles for intakes of calcium, iron, thiamine and riboflavin, excessive intakes of free sugar and Na were more prevalent among children with a higher EI from snacks.
Conclusions: Although snacks are effective in meeting the requirement of some nutrients among Japanese nursery school children, snacks are generally not nutrient-dense and have an impact on excessive intake of some nutrients. There is hence room for improvement in food choices at snack time.

Keywords
Children
Dietary survey
Nutritional adequacy
Snack

The prevalence of snacking behaviour and energy contribution from snacks have globally increased in recent decades[1–4], especially among children[1]. For example, snacks provide around 25–30 % of total energy intake (EI) among children in the United States and Australia[5,6]. Considering this situation, many countries and organisations provide recommendations about the quality and quantity of snacks[7,8]. The most common rationale for these recommendations is that snacks contribute to meeting energy and nutrient requirements[8]. Indeed, snacks provide a sufficient amount of nutrients that should be encouraged, such as vitamin C and dietary fibre[6,9], but also contribute to intakes of nutrients that should be limited, such as added sugars and SFA[5,6,9]. It has also been suggested that frequent snacking is associated with poor diet quality and obesity in children[10,11]. Thus, it is important to establish strategies to improve snack quality in children.

Snacking habits in Asia may differ from those in western countries. For example, the prevalence of snacking habits among children is low in China (66·1 %) compared to the United States (97·9 %)[5]. However, studies regarding snacking habits in Asian children are limited to those conducted in China[2,5,12]. Moreover, these studies have not assessed how snacks contribute to the improvement of nutrient adequacy. In Asian children, excessive added

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sugar intake is less prevalent[13–15], while insufficient calcium intake is more prevalent[16–19] than in western children. The prevalence of childhood underweight/overweight is estimated to vary even among Asian countries[17,20]. Therefore, the kind and amount of nutrients supplied by snacks should be clarified in each country.

In this cross-sectional study among Japanese nursery school children, we evaluated the dietary characteristics of snacks (i.e. prevalence and food composition) and the percentage contribution of snacks to daily intakes of energy, nutrients and foods. Moreover, we also assessed the relationship of EI from snacks with the prevalence of nutritional inadequacy.

Methods

Participants

This study was based on a multi-regional dietary survey named Dietary Observation and Nutrient intake for Good Health Research in Japanese young children (DONGuRI), which was conducted from October to December 2015. Details of this study have been reported elsewhere[15,16]. Briefly, with consideration to geographical diversity and feasibility, particularly for the recruitment of research dietitians, twenty-four of forty-seven prefectures were selected as the targeted area. The prefectures were selected from all over Japan.

Boys and girls aged 19–83 months were recruited at nursery schools by 323 dietitians who worked generally in nursery schools. In each prefecture, sixteen boys and sixteen girls were recruited: four aged 19–23 months, four aged 24–35 months, two aged 36–47 months, two aged 48–59 months, two aged 60–71 months and two aged 72–83 months. Children were considered eligible if they were apparently healthy and did not consume special diets, and their guardians were not dietitians or medical doctors and did not plan to move within a few months. Participation of only one child per household was permitted. As a result, 753 children from 315 nurseries participated. For analysis, we excluded 375 children aged <36 months (<3 years), because only 1-d dietary data were collected for these children. Thus, this analysis included 378 children (187 boys and 191 girls) aged 3–6 years. Written informed consent was obtained from a guardian of each child.

Dietary assessment

Dietary intake was assessed using semi-weighed 3-d dietary records. Recording days consisted of 2 weekdays (nursery days) and 1 weekend day, and were not consecutive. It is common practice in Japanese nursery schools to serve lunch and at least one snack. Foods and beverages the children consumed, as well as leftovers, were weighed and recorded by the research dietitians in the nursery schools, and by the guardians outside the nursery schools. The research dietitians instructed guardians on how to keep dietary records and gave them a digital kitchen scale (KD-812WH; Tanita), measuring spoon, measuring cup, recording sheets and an instruction sheet. The starting and ending time of each eating occasion was also recorded. When weighing was difficult (e.g. when eating out), guardians recorded the estimated amount of foods and drinks consumed. On the following nursery day of each recording day, recording sheets were checked by the research dietitians. In accordance with the research manual, research dietitians converted the estimated portion sizes into weights and coded all food items on the basis of values in the Standard Tables of Food Composition in Japan[21]. Food items not listed on the tables were assigned the nutrient values of similar foods. The dietary records were then submitted to the central office and checked by two dietitians.

The recording sheets consisted of the following sections of eating occasions: breakfast, lunch, dinner and snacks. Eating occasions other than snacks were considered as 'meals' regardless of the time of day or foods and beverages consumed. Thus, the definition of meals and snacks in this study was based on what guardians and dietitians considered as meals and snacks. In accordance with previous studies[3,10,11,22], guardians and dietitians were instructed to consider two eating events as distinct eating occasions when these were separated by a minimum of 15 min. Calculations of eating frequency were based on all eating occasions, or eating occasions providing a minimum of 209·2 kJ, considering comparability with previous studies[10,11,22]. Intakes of energy, nutrients and foods were calculated as the mean value of 3 d. Supplements were not considered in nutrient intake calculation, not only because the dietary supplement use in the previous month was rare in our population (3·5 %) but also because of the lack of a dietary supplement database in Japan. We estimated dietary free sugar, which was defined as all mono- and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and naturally occurring sugars in honey, syrups, fruit juices and fruit juice concentrate[23]. Each mono- and disaccharide content was listed for only 880 of the 2222 food items in the Standard Tables of Food Composition in Japan[21], with no information on free sugar. Thus, we calculated free sugar consumption with reference to a recently developed sugar database[15,24]. Briefly, the remaining 1342 items without saccharide content were complemented with assignment of available carbohydrate content of foods, results of literature search, or calculated values based on recipes[25]. Then, based on the saccharide content, free sugar content of 2222 food items was estimated in each of the food groups using a published step-wise method[26,27]. Food grouping was mainly based on the Standard Tables of Food Composition in Japan[21].

Assessment of other factors

Questionnaires designed for this study were answered by the guardians before dietary assessment was conducted. The questionnaires asked about parental educational level, parental occupation and household income. Information on time spent on certain activities (vigorous, moderate or sedentary activity) both on weekdays and weekend days was also obtained. For weekdays, activities outside of the nursery were reported because we assumed that guardians could not assess their children's activity in nurseries. Vigorous activity (running, ball play or swimming) was used as a surrogate marker of the habitual physical activity of children. Anthropometric measurements were conducted by research dietitians as part of this study or at routine health check-ups (within 1 month before the study period). Body height (to 0·1 cm) and weight (to 0·1 kg) of children were measured while children were wearing light clothing and no shoes. BMI was calculated by dividing weight (kg) by height-squared (m^2).

Energy misreporting

Energy misreporting, especially underreporting, cannot be completely excluded from any dietary assessment[28]. Thus, we examined if reported daily EI was comparable to the estimated energy requirement in Japanese Dietary Reference Intakes (DRIs), 2015[29] at the 'good' level. The plausibility of reported EI from snacks was roughly assessed by comparing body size (weight, height and BMI) and habitual physical activity according to EI from snacks.

Assessment of nutritional inadequacy

Nutrient intakes were compared to the age- and sex-specific reference values in Japanese DRIs, 2015[29]. In Japanese DRIs, estimated average requirement (EAR) is defined as 'the amount that would meet the nutrient requirements of 50 % of the population'. The percentage of children with intake less than the EAR suggests an estimated prevalence of inadequate intake within a group. Of the seventeen nutrients with EAR, three (iodine, selenium and molybdenum) were excluded from the evaluation because of insufficient data for these nutrients in the Standard Tables of Food Composition in Japan. In Japanese DRIs, tentative dietary goals (DG) for the prevention of lifestyle-related diseases were developed for the percentage of energy from protein, total fat, SFA and carbohydrate, and intakes of Na, K and dietary fibre. To estimate the prevalence of inadequate intake, we calculated the percentage of children who consumed a nutrient outside (below or above) the range of the DG.

For children aged 3–5 years, a DG is not available for dietary fibre, K and SFA. For dietary fibre and K, we determined a tentative DG mainly based on the median intake in children of that age in the National Health and Nutrition Survey 2010 and 2011[16]. For SFA, we tentatively applied the DG of adults to children of that age[16,30]. DG and EAR values for children aged 3–6 years are shown in Supplemental Table 1. Due to the lack of a recommendation for free sugar intake for Japanese, excessive free sugar intake was defined as ≥10 % of total EI, in accordance with the recommendation of the WHO[23].

Statistical analysis

Because the results did not differ by sex, analyses were conducted for boys and girls combined. We compared intakes of energy, nutrients and foods derived from snacks with those from meals using a paired *t* test. To evaluate the characteristics of snacks, the percentage contribution of snacks to the daily intakes of energy, nutrients and foods was also calculated. In accordance with previous studies[5,6], the percentage contribution to EI was used as a standard from which the degree of contribution of each nutrient was evaluated.

Then, children were classified into tertile categories of EI from snacks. The associations of demographic characteristics of children and their parents with the categories of EI from snacks were tested by the Mantel–Haenszel χ^2 test for categorical variables and by regression analysis for continuous variables. Relationships of the categories of EI from snacks to the daily intakes of energy and nutrients were tested using regression analysis, with median values of EI from snacks for each category as independent variables. The associations between the categories of EI from snacks and the prevalence of children with inadequate nutrient intakes were tested by the Mantel–Haenszel χ^2 test.

All statistical analyses were performed using SAS (version 9.4; SAS Institute Inc.). *P*-values <0·05 were considered statistically significant.

Results

Snacks were consumed by all children on the weekdays and 92·9 % of children in the weekend day. Mean snack frequency was 2·8 times per day (SD 1·2), but was 1·6 times per day (SD 0·65) for snacks providing a minimum of 209·2 kJ (Table 1). The mean frequency for meals was 3·0 times per day (SD 0·06). Table 2 shows that the mean reported daily EI was comparable to the estimated energy requirement for children aged 3–5 years (5439·2 kJ/d for boys and 5230 kJ/d for girls[29]). On average, EI from snacks was 1118·4 kJ/d (SD 445·9) and accounted for 19·5 % (SD 6·9) of total EI. As expected, snacks provided a lower amount of all nutrients than meals, except for no difference in free sugar. Relative to their energy contribution, snacks

Table 1 Characteristics of study participants (*n* 378)

	Mean	SD
Age (years)	4·5	1·1
Height (cm)*	106	8·4
Weight (kg)*	17·8	3·4
BMI (kg/m2)*	15·7	1·5
Frequency of meals (times per day)†	3·0	0·06
Frequency of snacks (times per day)†	2·8	1·2
Frequency of snacks of ≥209·2 kJ (times per day)†	1·60	0·65

*Missing (*n* 1).
†Breakfast, lunch and dinner were considered as 'meals' regardless of the time of the day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'.

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Table 2 Daily intake of nutrients with dietary goals or estimated average requirement among Japanese nursery school children (*n* 378)

	Total intake		Intake from meals*		Intake from snacks*			Contribution (%) of snacks to total intake	
	Mean	SD	Mean	SD	Mean	SD	*P*†	Mean	SD
Energy (kJ/d)	5741·6	996·2	4623·3	906·7	1118·4	445·9	<0·0001	19·5	6·9
Protein (% energy)	14·2	1·5	15·0	1·8	11·0	2·7	<0·0001	–	–
Total fat (% energy)	29·5	4·0	29·1	4·5	30·2	8·7	0·03	–	–
Carbohydrate (% energy)	56·3	4·5	55·8	5·0	58·7	9·0	<0·0001	–	–
SFA (% energy)	9·7	1·9	8·6	2·0	13·9	4·8	<0·0001	–	–
Free sugar (% energy)	7·6	3·1	4·9	2·4	18·3	9·3	<0·0001	–	–
Protein (g/d)	48·5	9·2	41·4	9·0	7·1	2·7	<0·0001	14·9	5·6
Total fat (g/d)	45·2	11·2	36·0	10·2	9·1	4·8	<0·0001	20·4	9·4
Carbohydrate (g/d)	189·4	34·0	149·9	29·6	39·5	16·9	<0·0001	20·8	7·6
SFA (g/d)	14·8	4·1	10·7	3·5	4·2	2·2	<0·0001	28·1	12·5
Free sugar (g/d)	26·2	11·9	13·6	7·3	12·6	8·6	0·09	46·2	19·7
Na (g NaCl equivalent per day)‡	5·8	1·5	5·3	1·5	0·5	0·3	<0·0001	8·8	4·9
Dietary fibre (g/d)	9·0	2·2	7·8	2·1	1·2	0·7	<0·0001	13·2	7·4
K (mg/d)	1771·2	353·6	1414·6	329·1	356·5	146·4	<0·0001	20·3	7·4
Vitamin A (μg RAE/d)§	400·2	220·0	337·1	220·1	63·1	38·8	<0·0001	17·2	10·1
Thiamine (mg/d)	0·7	0·2	0·6	0·2	0·1	0·05	<0·0001	15·5	6·9
Riboflavin (mg/d)	0·9	0·2	0·7	0·2	0·2	0·1	<0·0001	25·4	9·1
Niacin (mg NE/d)‖	17·9	4·2	16·0	4·1	2·0	0·9	<0·0001	11·4	5·0
Vitamin B_6 (mg/d)	0·9	0·2	0·7	0·2	0·1	0·07	<0·0001	13·6	7·3
Vitamin B_{12} (μg/d)	4·2	2·3	3·7	2·3	0·4	0·3	<0·0001	12·8	9·1
Folate (μg/d)	194·1	54·7	168·7	51·7	25·4	17·7	<0·0001	13·2	7·9
Vitamin C (mg/d)	71·8	30·5	60·0	27·1	11·8	13·1	<0·0001	15·9	13·7
Calcium (mg/d)	464·5	127·1	304·3	105·9	160·2	67·9	<0·0001	34·8	11·6
Magnesium (mg/d)	174·1	37·3	145·7	35·7	28·4	12·1	<0·0001	16·6	6·5
Iron (mg/d)	4·7	1·1	4·1	1·0	0·6	0·3	<0·0001	12·6	6·7
Zinc (mg/d)	5·9	1·1	5·0	1·1	0·9	0·3	<0·0001	15·3	5·7
Copper (mg/d)	0·7	0·2	0·6	0·1	0·1	0·06	<0·0001	13·8	6·7

NE, niacin equivalent; RAE, retinol activity equivalent.
*Breakfast, lunch and dinner were considered as 'meals' regardless of the time of day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'.
†Paired *t* test.
‡1 g NaCl equivalent = 58·5/23 × Na (g).
§1 μg RAE = sum of retinol (μg) + β-carotene (μg) × 1/12 + α-carotene (μg) × 1/12 + β-cryptoxanthin (μg) × 1/24.
‖1 mg NE = niacin (mg) + protein (mg)/6000.

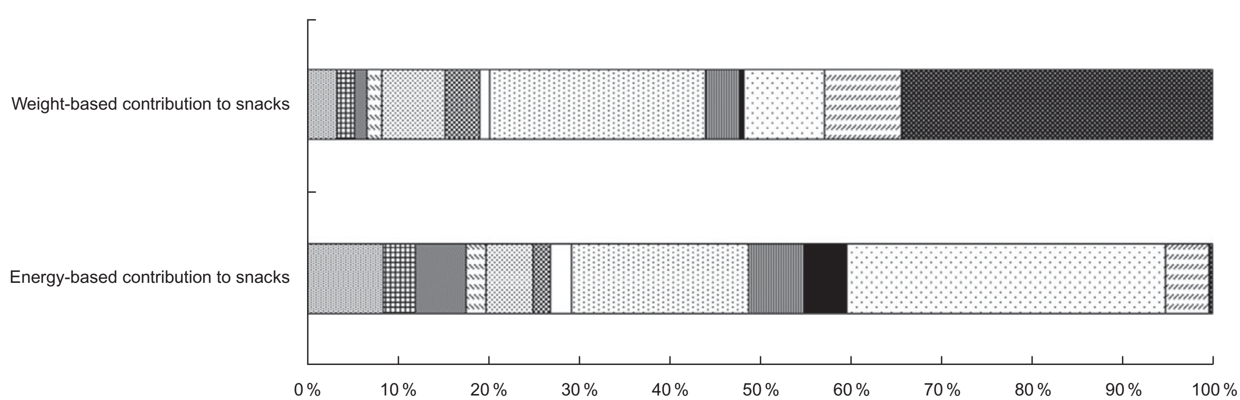

Fig. 1 Weight-based and energy-based contribution of food types to daily snack intake among Japanese nursery school children (*n* 378). Breakfast, lunch and dinner were considered as 'meals' regardless of the time of day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'. Population proportions were calculated by summing the weights (or energies) of a given food group for all persons and then dividing it by the sum of weights (or energy intakes) for all food groups consumed by all persons. ▩, White rice, noodle, breads; ▩, fruit; ▩, dairy products; ▩, tea and coffee drinks; ▦, potato; ▩, fruit/vegetable juice; ■, fats and oils; ▩, sugar; □, fish, meat, eggs; ▩, confectionaries; ▧, pulses, nuts, total vegetables; ▩, milk; ▨, sweetened drinks

accounted for a small proportion of daily intake of all nutrients except for free sugar (46·2 %), calcium (34·8 %), SFA (28·1 %) and riboflavin (25·4 %). Tea/coffee drinks (34·5 %) and milk (23·7 %) accounted for the greatest part of the food weight of snacks (Fig. 1). Confectionaries accounted for the largest part of EI from snacks (35·3 %), followed by milk (19·5 %). Most foods were mainly consumed as part of meals, but 73·3 % of confectionaries,

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Table 3 Characteristics of Japanese nursery school children and their parents according to tertile categories of energy intakes from snacks*

	Tertile categories of energy intakes from snacks						
	Lowest		Middle		Highest		
	n 126		*n* 126		*n* 126		
	Mean	SD	Mean	SD	Mean	SD	*P*†
Age (years)	4·4	1·1	4·5	1·1	4·6	1·1	0·11
Height (cm)‡	105·2	8·3	105·4	8·8	107·5	7·9	0·02
Weight (kg)‡	17·5	3·6	17·5	3·4	18·3	3·3	0·049
BMI (kg/m^2)‡	15·7	1·7	15·6	1·3	15·7	1·4	0·74
	%		%		%		
Male sex	47·6		48·4		52·4		0·45
Vigorous outdoor activity on weekday (h/d)‡							
<0·5	85·6		83·3		79·4		0·32
0·5 to <1·0	8·8		13·5		15·1		
1·0 to <2·0	3·2		0·8		4·8		
2·0 to <3·0	1·6		0·8		0		
≥ 3·0	0·8		1·6		0·8		
Vigorous outdoor activity on weekend (h/d)‡							
<0·5	15·2		11·1		9·5		0·04
0·5 to <1·0	34·4		19		29·4		
1·0 to <2·0	29·6		43·7		31		
2·0 to <3·0	14·4		15·1		19·8		
≥3·0	6·4		11·1		10·3		
Paternal education (years)‡							
≤12	35·5		29·7		35·2		0·42
13–14	23·1		15·3		32·0		
≥15	41·3		55·1		32·8		
Maternal education (years)‡							
≤12	20·0		19·8		22·2		0·20
13–14	44·0		46·0		50·8		
≥15	36·0		34·1		27·0		
Paternal occupation‡							
Professional and manager	45·1		46·6		40·2		0·20
Office work, service and sales	29·5		29·7		23·0		
Manual	22·1		22·9		35·2		
Unemployed, unknown	3·3		0·8		1·6		
Maternal occupation‡							
Professional and manager	53·6		47·6		44·4		0·39
Office work, service and sales	35·2		42·9		38·9		
Manual	7·2		6·3		11·9		
Unemployed, unknown	4·0		3·2		4·8		
Household income (yen)‡							
<4 000 000	19·2		28·5		22·4		0·007
4 000 000 to <6 000 000	28·8		32·5		30·7		
6 000 000 to <8 000 000	24·8		23·6		21·0		
≥8 000 000	27·2		15·4		25·9		

*Breakfast, lunch and dinner were considered as 'meals' regardless of the time of day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'. Median (range) energy intake from snacks in each category was 703·0 kJ/d (208·9–855·0), 1068·4 kJ/d (867·9–1272·5) and 1531·4 kJ/d (1273·4–3009·1), respectively.

†Regression analysis using median values of energy intakes from snacks for each category as independent variables. Mantel–Haenszel χ^2 test or Fisher's exact test for categorical variables.

‡Data were missing for height (*n* 1), weight (*n* 1), BMI (*n* 1), vigorous outdoor activity on weekday and weekend (*n* 1), paternal education (*n* 17), maternal education (*n* 1), paternal occupation (*n* 16), maternal occupation (*n* 1) and household income (*n* 7).

59·7 % of milk and 57·4 % of sweetened drinks were consumed in snacks (Supplemental Table 2).

Mean age and BMI as well as the sex prevalence of children did not differ among tertile categories of EI from snacks (Table 3). However, children with a higher intake of EI from snacks were taller, heavier and spent more time in vigorous outdoor activity on weekend days. Mean EI from snacks in the lowest, middle and highest tertile categories was 664·6 kJ/d (SD 140·6), 1068·4 kJ/d (SD 125·0) and 1622·2 kJ/d (SD 313·8), respectively (Fig. 2). The tertile categories of EI from snacks were not associated with EI from meals (P_{trend} = 0·63) but were positively associated with total EI (P_{trend} < 0·0001). EI from snacks was positively associated with daily intakes of all nutrients with EAR or DG, except for vitamin A, vitamin B_6, vitamin B_{12} and vitamin C (Table 4). The prevalence of children consuming K below the DG, and thiamine, riboflavin, calcium and iron below the EAR, was low in children with high EI from snacks (Table 5). However, 50 % of children consumed inadequate calcium even in the highest category of EI from

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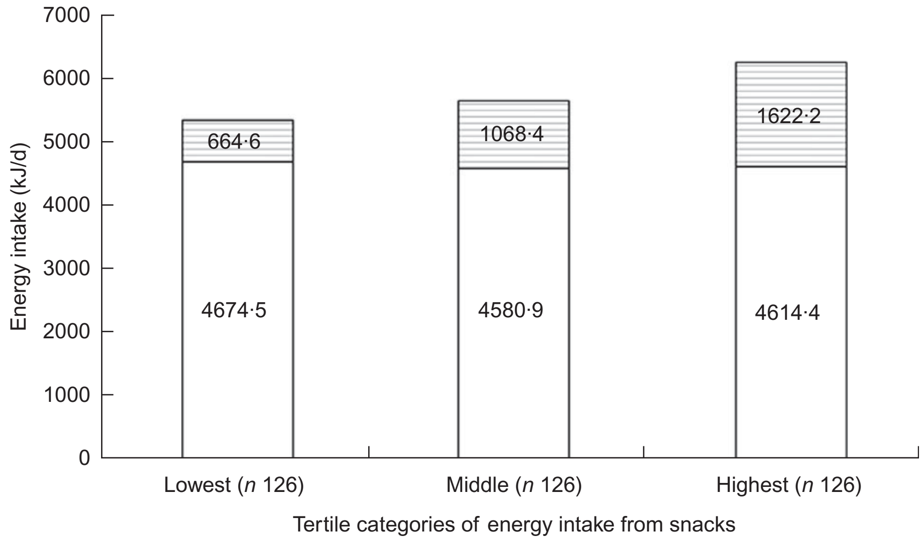

Fig. 2 Mean daily energy intake from meals and snacks according to tertile categories of energy intakes from snacks among Japanese nursery school children (*n* 378). Breakfast, lunch and dinner were considered as 'meals' regardless of the time of day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'. P_{trend} was calculated based on a regression analysis using median values of energy intakes from snacks for each category (703·0, 1068·4 and 1531·4 kJ/d, respectively) as independent variables. $P_{trend} < 0{\cdot}0001$ for energy intake from snacks, $P_{trend} = 0{\cdot}63$ for energy intake from meals, and $P_{trend} < 0{\cdot}0001$ for total energy intake. □, Energy intake from meals; ▤, energy intake from snacks

Table 4 Daily intake of nutrients with dietary goals or estimated average requirement according to tertile categories of energy intakes from snacks* among Japanese nursery school children

	Tertile categories of energy intakes from snacks						
	Lowest		Middle		Highest		
	n 126		*n* 126		*n* 126		
	Mean	SD	Mean	SD	Mean	SD	*P*†
Protein (% energy)	14·6	1·6	14·2	1·6	13·8	1·3	<0·0001
Total fat (% energy)	29·2	4·0	29·8	4·0	29·4	4·1	0·71
Carbohydrate (% energy)	56·2	4·5	56·0	4·4	56·8	4·5	0·26
SFA (% energy)	9·4	1·9	9·9	1·9	9·9	1·9	0·047
Free sugar (% energy)	6·2	2·5	7·3	2·6	9·2	3·3	<0·0001
Protein (g/d)	46·5	9·1	48·0	9·4	51·1	8·6	<0·0001
Total fat (g/d)	41·5	9·9	45·1	11·2	48·9	11·2	<0·0001
Carbohydrate (g/d)	175·6	31·4	184·9	28·5	207·8	33·6	<0·0001
SFA (g/d)	13·3	3·6	14·9	4·0	16·4	4·1	<0·0001
Free sugar (g/d)	19·7	8·6	24·7	9·5	34·0	12·5	<0·0001
Na (g NaCl equivalent per day)‡	5·6	1·5	5·6	1·5	6·2	1·5	0·002
Dietary fibre (g/d)	8·5	2·0	9·0	2·2	9·5	2·3	0·0002
K (mg/d)	1692·2	339·9	1758·2	356·9	1863·1	345·4	<0·0001
Vitamin A (μg RAE/d)§	399·6	296·3	398·5	189·6	402·6	149·1	0·91
Thiamine (mg/d)	0·64	0·15	0·67	0·17	0·70	0·16	0·004
Riboflavin (mg/d)	0·87	0·22	0·91	0·21	0·99	0·20	<0·0001
Niacin (mg NE/d)‖	17·3	4·2	17·8	4·2	18·6	4·1	0·015
Vitamin B_6 (mg/d)	0·84	0·23	0·84	0·19	0·88	0·21	0·08
Vitamin B_{12} (μg/d)	4·0	2·3	4·1	2·3	4·4	2·4	0·21
Folate (μg/d)	187·6	57·3	193·5	54·7	201·1	51·6	0·048
Vitamin C (mg/d)	70·8	31·1	70·6	31·4	73·9	28·9	0·40
Ca (mg/d)	427·5	120·9	462·5	121·6	503·5	128·2	<0·0001
Mg (mg/d)	166·2	36·2	171·6	37·2	184·4	36·4	<0·0001
Fe (mg/d)	4·4	1·1	4·6	1·1	5·0	1·1	<0·0001
Zn (mg/d)	5·7	1·2	5·9	1·1	6·2	1·0	0·002
Cu (mg/d)	0·71	0·16	0·74	0·15	0·8	0·2	<0·0001

NE, niacin equivalent; RAE, retinol activity equivalent.
*Breakfast, lunch and dinner were considered as 'meals' regardless of the time of day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'. Median (range) energy intake from snacks in each category was 703·0 kJ/d (208·9–855·0), 1068·4 kJ/d (867·9–1272·5) and 1531·4 kJ/d (1273·4–3009·1) respectively.
†Regression analysis using median values of energy intakes from snacks for each category as independent variables.
‡1 g NaCl equivalent = 58·5/23 × Na (g).
§1 μg RAE = sum of retinol (μg) + β-carotene (μg) × 1/12 + α-carotene (μg) × 1/12 + ββ-cryptoxanthin (μg) × 1/24.
‖1 mg NE = niacin (mg) + protein (mg)/6000.

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Table 5 Prevalence of inadequate intake of selected nutrients according to tertile categories of energy intakes from snacks among Japanese nursery school children*

	Tertile categories of energy intakes from snacks			
	Lowest *n* 126	Middle *n* 126	Highest *n* 126	
	Prevalence of inadequacy			
	%	%	%	*P*†
Nutrient with DG				
Protein < DG lower limit	18·3	24·6	28·6	0·05
Protein > DG upper limit	0·8	0	0	–
Total fat < DG lower limit	0	0·8	2·4	–
Total fat > DG upper limit	40·5	48·4	45·2	0·45
Carbohydrate < DG lower limit	7·1	9·5	7·1	0·99
Carbohydrate > DG upper limit	4·8	3·2	4·8	–
SFA > DG	90·5	96·8	95·2	0·11
Na > DG	73·0	74·6	88·1	0·004
Dietary fibre < DG	57·9	54·0	46·8	0·08
K < DG	34·1	31·0	19·0	0·008
Nutrient with EAR				
Protein	0	0	0	–
Vitamin A	38·9	27·8	30·2	0·14
Thiamine	46·8	42·9	31·7	0·01
Riboflavin	15·9	12·7	0·8	<0·0001
Niacin	0	0	0	–
Vitamin B_6	3·2	4·8	1·6	–
Vitamin B_{12}	0	0	0	–
Folate	0	0	0	–
Vitamin C	7·9	9·5	9·5	0·66
Ca	71·4	57·1	50·0	0·0005
Mg	0	0·8	0	–
Fe	33·3	28·6	15·9	0·002
Zn	0·8	0	0	–
Cu	0	0	0	–
Nutrient with WHO recommendation				
Free sugar	4·8	16·7	36·5	<0·0001

DG, dietary goal; EAR, estimated average requirement.
*Breakfast, lunch and dinner were considered as 'meals' regardless of the time of day or foods and beverages consumed. Eating occasions other than meals were considered as 'snacks'. Median (range) energy intake from snacks in each category was 703·0 kJ/d (208·9–855·0), 1068·4 kJ/d (867·9–1272·5) and 1531·4 kJ/d (1273·4–3009·1), respectively.
†Mantel–Haenszel test was conducted for nutrients for which at least 5 % of participants were classified as having inadequate intake.

snacks. The prevalence of children exceeding the DG for Na was >70 % in all categories, and was higher among children with high EI from snacks. Over 90 % of children in each category had an SFA intake exceeding the DG, with no significant differences among categories. The prevalence of excessive free sugar intake (≥10 % of EI) was higher among children with a higher EI from snacks. EI from snacks was positively associated with the daily intakes of sugars as seasonings, fruit, milk, confectionaries and sweetened drinks (Supplemental Table 3).

Discussion

To our knowledge, this is the first study to show the characteristics of snacks and the prevalence of nutritional inadequacy according to EI from snacks among Japanese nursery school children. Snacking habits are very prevalent, and snacks provide one-fifth of daily EI. However, the largest part of EI from snacks is supplied by confectionaries, and snacks are generally not nutrient-dense but rather energy-dense. Children with higher EI from snacks were less likely to have inadequate intake of thiamine, riboflavin, calcium and iron, but more likely to have excess intake of free sugar and Na. There is a room for improvement in food choices and diet quality at snack time among nursery school children.

The prevalence of snacking was much higher in our participants than Chinese children[5]. The percentage of EI from snacks was lower than that reported in some countries (26·6 % in the United States and 32·9 % in Australia)[5], but higher than that in other countries (11·9 % in China and 15·4 % in Mexico)[5]. A high prevalence of snacks in this population might be explained by the fact that snacks are regularly offered at nursery schools in Japan, even though snacks are also prevalent on the weekend. Snacks might have a greater impact on the diet quality of children in Japan than in China. EI from snacks was independent of that from meals, suggesting that EI from snacks is not compensated for by EI from meals. Although overweight is not prevalent (<5 %) in Japanese nursery school children[20], excess EI and overweight due to frequent snacking is of concern[11]. However, this does not mean that snacking should be avoided. In developed countries, children commonly have four or more eating occasions per day[10,11,31,32]. The EI needed for a healthy growth of children is considered to be not fully supplied by breakfast, lunch and dinner alone. Strategies aimed at promoting a healthy growth of children should not attempt to stop snacking but rather must improve the quality of snacks.

A large part of EI from snacks is derived from confectionaries, and a higher EI from snacks is associated with excess free sugar intake. Confectionaries as well as sweetened drinks are the main contributors to free sugar consumption in Japanese nursery school children[15]. Among children in Scotland, confectionaries are consumed not only in snacks but also with meals, and soft drinks are more frequently consumed as part of a meal than a snack[33]. Considering that the consumption of these foods as meals is not common in our participants, snacking habits appear to be the main target in controlling free sugar intake among Japanese nursery school children.

Compared to sweetened drinks, tea/coffee drinks and milk account for a larger part of the food weight of snacks. Considering free sugar consumption, this is a favourable aspect of beverage intake during snacking in Japanese nursery school children. Moreover, the relatively adequate calcium and riboflavin intakes among children with higher EI from snacks could be explained by the higher intake of milk and dairy products during snacking. Milk and dairy products are also popular snack items in other countries[5,6,31], and thus snacking on such foods is an effective way to improve calcium and riboflavin intake in children. In contrast, intakes of SFA should be limited both in meals and snacks because excessive intake of SFA prevails regardless of EI from snacks. Replacing regular-fat dairy with low-fat dairy could reduce EI from SFA without changing calcium intake[34,35]. Although low-fat dairy is recommended for children in some countries[36,37], there is no consensus on this topic in Japan. Considering all the foods consumed as snacks by Japanese children (Supplemental Table 2), a low EI from milk fat might be compensated for by a higher free sugar intake from soft drinks or confectionaries. Further discussion is needed based on scientific evidence in children regarding the effects of SFA restriction on blood lipids, growth and development[38–40], as well as the energy compensation caused by a shift to low-fat milk[35,41]. On the other hand, although EI from snacks was positively associated with inadequate Na intake, interventions for Na reduction should mainly target meals, because the contribution to Na intake from snacks was relatively small (8·8 %).

Although snacks did not substantially contribute to intakes of iron and thiamine, the prevalence of inadequate thiamine and iron intake was low in children with a higher EI from snacks. This was because many children had intakes near the EAR, and a small increase in intake changed the proportion of children with inadequate intake. Considering that anaemia is common after first menstruation[42], iron-rich foods should be incorporated into snacks for girls for both this purpose and for growth.

Snacking is a common way to incorporate fruits into the diet in the United States and China[12,43]. Contrary to studies in these countries[5,6], however, the contribution to daily vitamin C and dietary fibre intake from snacks, relative to its energy contribution in our participants, was small, which might be due to a relatively low consumption of fruits during snacking. Substituting confectionaries with fruits might be an effective way to reduce free sugar and SFA intakes from snacks, as well as to increase intakes of dietary fibre, vitamins C and K.

Several limitations of this study should be mentioned. First, systematic and random errors in dietary assessment could not be completely eliminated. Dietary assessment was based on only three recording days in November (autumn), and thus day-to-day and seasonal variations might have biased our findings. The positive association between EI from snacks and daily nutrient intake might be partly explained by an underreporting of eating frequency[44]. However, children with a higher EI from snacks were physically more active on weekend days than those with a lower EI from snacks. Moreover, the mean reported daily EI was comparable to the estimated energy requirement for children aged 3–5 years[29]. Thus, we considered that the reported EI from snacks was plausible. Second, eating occasions were classified based on the self-reports of guardians. There are various definitions of snacks[45], and the definition may affect the observed association between snacking frequency and diet quality[46,47]. Thus, the results of this study should be interpreted based on the definition used in this study. Third, generalisability is likely limited because all of our study participants were nursery school children, and the selection of participants as well as of study areas was not randomised. Around 50 % of children aged 3–6 years attend nursery schools in Japan[48]. Snacks offered at nursery schools are controlled by dietitians and would be healthier than those consumed in other locations. Thus, the positive (or negative) impact of snacking on nutrient adequacy might be overestimated (or underestimated). Although geographic diversity was considered, study areas were limited to twenty-four prefectures because collaborators (research dietitians) were recruited from the personal connections of dietitians. Further studies based on a more representative data are needed to clarify the differences between snacks consumed at nursery schools, at home and elsewhere[49].

Conclusions

Although snacks contribute to meeting the requirements for some nutrients among Japanese nursery school children, snacks are generally not nutrient-dense and are associated with an excessive intake of free sugar. Food choice at snack time has room for improvement, such as substituting confectionaries with fruits. Further studies in Asia should be conducted to establish the effective ways to improve nutrient adequacy among children, with consideration to specific eating occasions.

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Supplementary material

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