

Original Article

Free sugar intake and dietary sources in rural Japanese infants aged 18–23 months

Yohei Horikawa MD¹, Shuichi Yatsuga MD, PhD^{2,3}, Yuki Okamatsu MD, PhD⁴

¹*Zendoji Kodomo Clinic, Fukuoka, Japan*

²*Department of Medical Genetics, Goryokaku Hospital, Hokkaido, Japan*

³*Department of Pediatrics, Fukuoka University, Fukuoka, Japan*

⁴*Department of Pediatrics, Iizuka Hospital, Fukuoka, Japan*

Background and Objectives: Optimizing sugar intake during early childhood is critical for preventing noncommunicable diseases. Although international guidelines recommend limiting free sugar intake, Japan is yet to consolidate data on free sugar intake among children under 2 years of age. This study examined free sugar intake, dietary sources, and associated factors among Japanese children aged 18–23 months. **Methods and Study Design:** A cross-sectional study was conducted among children attending infant health checkups in Kama City, Japan. Caregivers recorded two non-weighted dietary records (one weekday and one Sunday). Free sugar intake, dietary sources, and related factors were analyzed. **Results:** Among 84 participants, the mean free sugar intake was 13.3 g/day, corresponding to 5.7% of estimated energy requirements. Overall, 44.0% of children exceeded the World Health Organization recommended level of <5% of energy from free sugar, and 16.7% exceeded the <10% threshold. Major sources included confectioneries (43.2%), fruits including 100% fruit juice (27.3%), dairy products (23.3%), and sweetened beverages (4.6%). Free sugar intake was 37% higher on Sundays than on weekdays. Multivariable analyses showed no significant associations between excessive free sugar intake and demographic or lifestyle characteristics. **Conclusions:** A substantial proportion of Japanese infants aged 18–23 months consumed free sugar in excess of World Health Organization recommendations. These findings highlight the need to improve caregiver awareness of major free sugar sources, particularly 100% fruit juice, and support the development of age-specific dietary guidance and pediatric nutrition counseling in Japan.

Key Words: dietary sugars, Japan, infant, caregivers, feeding behavior

INTRODUCTION

Childhood obesity has emerged as a critical global health challenge,¹ with its prevalence having increased by over tenfold from 11 million cases in 1975 to 124 million in 2016.² Although Japan has maintained lower childhood obesity rates compared to other high-income countries, national-level data show an upward trend in childhood overweight and obesity in recent decades, raising public health concerns in Japan as well as globally,^{2,3} and this trend is particularly alarming given its established role as a risk factor for noncommunicable diseases (NCDs),² including cardiovascular disease^{4,5} and type 2 diabetes.⁶ In Japan, rural–urban differences in diet-related health have also been documented, with children in rural areas showing a greater increase in obesity prevalence over time.⁷

Growing evidence has demonstrated a close link between dietary habits—particularly the consumption of added sugar and free sugar, and the development of NCDs.^{6,8,9} Sugar intake in children has been associated with elevated risk for cardiovascular diseases through multiple mechanisms, including increased energy intake, enhanced adiposity, and dyslipidemia.⁸ Recognizing this, the American Academy of Pediatrics has emphasized the need for pediatricians to play an active role in reducing

children's added sugar intake.¹⁰

In 2015, the World Health Organization (WHO) issued guidelines recommending that free sugar intake—defined as sugars added to foods and drinks and those naturally present in honey, syrups, and fruit juices—should be less than 10% of total energy intake, with a conditional recommendation for an ideal level below 5%.¹¹ This recommendation provides a standardized reference for evaluating sugar consumption relative to total energy intake, enabling international comparisons across populations. In response, countries including the United States,¹² the United Kingdom,¹³ Canada,¹⁴ Germany,¹⁵ Korea,¹⁶ and China¹⁷ have established national sugar intake guidelines. Notably, the US 2020–2025 Dietary Guidelines recommend avoiding added sugars entirely for children under 2

Corresponding Author: Dr Shuichi Yatsuga, Department of Pediatrics, Fukuoka University, 7-45-1 Nanakuma, Jonan-ku, Fukuoka City, Fukuoka, 814-0180, Japan

Tel: +81-92-801-1011; Fax: +81-92-862-8200

Email: s.yatsuga@fukuoka-u.ac.jp

Electronic supplementary information available. See apjcn.qdu.edu.cn/35_5_844_supp.pdf

Manuscript received 23 January 2026. Initial review completed 20 May 2026. Revision accepted 28 June 2026.

doi: 10.6133/apjcn.202610_35(5).0010

years of age,¹² citing concerns about early taste preference formation and diet quality.¹⁸⁻²¹

The first 1,000 days of life—from conception to age 2—represent a critical window in which nutrition has lasting impacts on physical growth, cognitive development, and long-term health outcomes.^{22,23} Dietary patterns established in this period often persist beyond infancy,²⁴ making early life a key target for preventive strategies. Studies from several countries have reported that many infants and toddlers under 2 years of age consume free sugar in excess of recommended levels.²⁵⁻²⁷

Despite these global trends, Japan has not yet established official sugar intake standards for children, nor do current nutrition labels indicate free sugar content.²⁸ These gaps hinder public understanding and the promotion of sugar-related dietary behavior change.

To date, only eight studies have assessed sugar intake in Japanese children,²⁹⁻³⁶ with none specifically focusing on those under 2 years of age. These eight studies covered children aged 18 months to 19 years. Among them, Fujiwara et al. reported free sugar intake levels specifically for children under 2 years of age.³³ Regarding older children, Fujiwara et al. noted that 21.7% of Japanese children aged 3–6 years exceeded the WHO recommendation of <10% of total energy intake from free sugar.³⁴ This lack of data is concerning, given the recognized importance of establishing healthy dietary habits early in life.

Considering the absence of national guidelines and the limited evidence base, it is essential to quantify sugar intake among Japanese children under 2 years and explore contributing factors. This study aimed to assess free sugar intake and its dietary sources among children aged 18–23 months and examine potential associations with demographic and lifestyle characteristics. Our focus on children aged 18–23 months was guided by international and national policy considerations. For example, the Dietary Guidelines for Americans 2020–2025 identify children under 2 years of age as a distinct population requiring specific dietary guidance.¹² In Japan, the national health promotion strategy, Health Japan 21 (the third term), also emphasizes the relevance of establishing healthy lifestyle behaviors, including eating habits, from infancy as part of a life-course approach.³⁷ Altogether, we focused our investigation on this high-impact developmental window. These findings may help inform pediatric nutrition counseling and future guideline development in Japan.

METHODS

Study setting and participants

This cross-sectional study was conducted from January 2022 to April 2024 as part of the municipal health surveillance program in Kama City, Fukuoka Prefecture, Japan. It was approved by the Institutional Review Board of Iizuka Hospital (approval number 21075) through an expedited review and conducted in accordance with the Declaration of Helsinki. Because the data were collected anonymously, the requirement for informed consent was waived by the ethics committee. Kama City, a rural municipality with approximately 40,000 residents, offers a statutory 1.5-year health checkup program covering over

95% of eligible children. All infants aged 18–23 months attending the mandatory checkup during the study period were eligible. This age range corresponds to the standardized timing of the municipal health checkup in Japan. Children were included if they were legal residents of Kama City, aged 18–23 months at the checkup, and had completed it. Exclusion criteria included chronic conditions requiring ongoing care; gestational age <37 weeks and birth weight <2,500 g; acute illness (fever $\geq 37.5^{\circ}\text{C}$, vomiting, or diarrhea within 7 days); or current use of oral medications, including supplements. Preterm and low-birth-weight infants were excluded due to known links with feeding difficulties and different nutritional needs.^{38,39}

Data collection and survey procedures

Study request forms, a dietary intake questionnaire, and a daily life questionnaire were mailed to caregivers along with the city's official health checkup documents. All participants were children aged 18–23 months. Caregivers recorded their child's intake on one weekday and one Sunday using a non-weighed dietary record, a method validated in infants and young children aged 6–24 months that accounts for daily intake variability.^{40,41} Caregivers were instructed to record all foods and beverages consumed by the child using a structured form, developed in Japanese. Sugar-sweetened beverage intake was assessed using the same caregiver-reported dietary records, including product names and intake amounts. The form included examples of popularly consumed commercial foods and portion size indicators using household measurements (e.g., “1 bottle” and “1 pack”). Completed records were independently reviewed by two registered dietitians. Any discrepancies were resolved through discussion to ensure data accuracy and consistency. The dietary record and questionnaire were specifically designed in Japanese and did not require translation or cultural adaptation. Only commercially available foods with dietary labeling were included, per the Food Labeling Standards defined by the Consumer Affairs Agency of Japan.⁴² Target items included both solid foods and beverages consumed at breakfast, lunch, dinner, and snack times. Data collection was restricted to commercially available foods with nutrition labeling to ensure reliable estimation of free sugar intake and minimize caregiver burden. Previous studies in Japan have observed that most free sugar consumed by young children is derived from labeled products, such as confectioneries and beverages.³³

Measurements

Two registered dietitians estimated the free sugar content of foods recorded on both days. Free sugar was defined as all monosaccharides and disaccharides added by the manufacturer, cook, or consumer, plus sugars naturally present in honey, syrups, fruit juices, and juice concentrates, in line with WHO guidelines.¹¹ Naturally occurring sugars in intact fruits, vegetables, and plain dairy products were excluded from the calculations. Since nutrition labels in Japan do not state free sugar content, we used the stepwise method by Louie et al.,⁴³ adapted by Fujiwara et al.³³ Unlike Louie et al.,⁴³ who measured added sugars, we included fruit juice concentrates to reflect the WHO

definition. Food items were classified into 18 food groups based on the Standard Tables;⁴⁴ in this food group classification, “fruits” refer to fruit products containing free sugars (e.g., 100% fruit juice), whereas “dairy products” represent sweetened dairy foods (e.g., flavored milk, sweetened yogurt). Intact fruits and plain unsweetened dairy products were outside the scope of the present analysis and were not included in the calculation of free sugar intake. Total sugar, not listed on Japanese labels, was defined as the sum of glucose, fructose, galactose, sucrose, lactose, maltose, and trehalose.⁴⁵ It was estimated using the 2020 Standard Tables of Food Composition in Japan⁴⁴ and Fujiwara et al.’s method.³³ Details on sugar measurement are provided in Supplementary Material (Figures 1 and 2, Tables 1 and 2). Briefly, free sugar was assessed using an eight-step approach aligned with WHO’s definition. Total sugar was calculated with a six-step method from Fujiwara et al.³³

Assessment of characteristics and lifestyle factors

The daily life questionnaire covered child sex, height, weight, number of siblings, sleep duration, dental caries treatment history, childcare attendance, screen time, coresidence with grandparents, maternal age at delivery, parental smoking status, and caregiver occupation. Parental smoking status was collected as four categories: neither parent, father only, mother only, or both. Caregiver occupation was collected as managerial/professional, office, sales, service, manual labor, other, or unemployed.

These data were collected using a self-administered questionnaire completed by the caregivers. The questions were developed in Japanese based on national and international guidelines and reviewed for clarity and comprehension by several caregivers; however, no validation was conducted. Height and weight were measured during the checkup by trained public health nurses using standardized procedures and equipment,⁴⁶ and recorded to the nearest 0.1 cm and 0.1 kg. A sleep duration of <11 h was defined as short sleep, and that exceeding 11 h was defined as reasonable since the recommended sleep duration for children aged 1 year is 11–14 h.⁴⁷ A screen time of <30 min was defined as adequate, whereas that over 30 min was defined as excessive based on the recommended screen time for children under 2 years of age.^{48–50} Maternal age was categorized using 30.9 years, the national average at first birth in Japan.⁵¹ This cutoff was selected to provide a population-based reference while maintaining sufficient group sizes for exploratory analyses.

Statistical analysis

Excessive free sugar intake was defined as $\geq 10\%$ and $\geq 5\%$ of total energy intake, per WHO recommendations.¹¹ As actual energy intake was not measured, estimated energy requirements (EERs) from the Japanese Dietary Reference Intakes (2020) were used:²⁸ 950 kcal/day for boys and 900 kcal/day for girls, calculated as the sum of energy expenditure and accumulation. This approach has been applied in previous early childhood nutrition studies where direct energy measurement was not feasible.^{25,52,53} Total energy intake was not evaluated because the survey focused solely on commercially available foods with nutrition labeling. This restriction was

established because previous studies suggest that most free sugar consumed by children under 2 years was derived from such products;³³ this is because a simplified dietary record was essential for minimizing caregiver burden and maximizing response rates. Requiring caregivers to record all foods, including meals prepared at home and at restaurants, may reduce data accuracy and response. Food sources contributing to free sugar were grouped using the same 18 food categories.⁴⁴ Descriptive statistics summarized all variables: means and standard deviations for continuous variables, and counts and percentages for categorical ones. Univariate analyses compared excessive vs. adequate intake groups. Fisher’s exact test was used for categorical variables; the Wilcoxon rank-sum test for continuous ones. To compare the distribution of food group contributions to total free sugar intake between weekdays and Sundays, an exploratory chi-square test was performed using the total amount of free sugar contributed by each food group on weekdays and Sundays. Univariate analyses were performed as exploratory assessments to examine individual associations between each variable and excessive free sugar intake before multivariable logistic regression analyses. Logistic regression analyzed the association between selected binary independent variables (child sex, sleep duration, screen time, maternal age at delivery, and parental smoking status) and excessive free sugar intake ($\geq 10\%$ E and $\geq 5\%$ E).

These variables were chosen a priori based on previous literature,^{34,54,55} clinical relevance, availability in the questionnaire, and the need to avoid overfitting given the small sample size. They were dichotomized as follows: child sex (reference: boys), sleep (reference: ≥ 11 h),⁴⁷ screen time (reference: <0.5 h/day),^{48–50} maternal age (reference: ≤ 30 years), and parental smoking status (reference: neither parent). For the regression analyses, all variables were entered as binary indicator variables, not as ordinal or continuous variables. Parental smoking status, originally collected in four categories, was dichotomized as any parental smoking versus neither parent for the regression analyses. The reported odds ratios therefore represent the odds of excessive free sugar intake in the category of interest compared with the specified reference group. No adjustments for multiple comparisons were performed, as the analyses were exploratory. Odds ratios (ORs), 95% confidence intervals (CIs), and *p*-values were reported. All analyses were performed using Stata 19.5 (StataCorp, College Station, TX, United States), with two-sided *p*-values <0.05 considered statistically significant.

RESULTS

Study participation and sample selection

A total of 248 questionnaires were distributed to families of children eligible for the 1.5-year health checkup. Among the distributed questionnaires, 25 were provided to families whose infants did not complete the checkup, leaving 223 eligible participants. Among the eligible participants, 166 returned the questionnaires, yielding a response rate of 74.4%. After excluding 4 participants with incomplete demographic information and 70 with insufficient dietary records, 92 participants remained for the

initial review. Among 92 remaining participants, 6 were excluded for meeting the medical exclusion criteria and having insufficient dietary recording days, and 2 were excluded for other predefined criteria. Consequently, the final sample for analysis comprised 84 infants (46 boys [54.8%] and 38 girls [45.2%]) (Figure 1, Table 1). Among the 82 questionnaires excluded, 58 contained sufficient demographic information to permit group-level comparisons. Additional analyses comparing the analytic and excluded groups showed no significant differences in sex, BMI, sleep duration, childcare attendance, caregiver occupation, or other core demographic characteristics, suggesting that selection bias related to sample exclusion was likely minimal.

Free sugar intake patterns

Mean daily intake of free sugar was 13.3 g (standard deviation [SD]; 10.5), with the intake being higher on Sunday (15.2 g) than on weekdays (11.1 g), representing a non-significant trend toward a 37% increase ($p = 0.083$, Wilcoxon signed-rank test). When expressed as a percentage of total energy intake (estimated from age- and sex-specific EERs), the mean contribution of free sugar was 5.7% (SD 4.6), with 4.8% (SD 4.6) on weekdays and 6.6% (SD 6.2) on Sundays. The median daily intake was 10.6 g (interquartile range [IQR] 5.4–18.2 g), indicating a right-skewed distribution.

A tendency toward higher energy intake from free sugar was observed among girls (mean 6.1%) compared to boys (mean 5.5%), although this difference was not statistically significant ($p = 0.50$, Wilcoxon signed-rank test).

Prevalence of excessive free sugar intake

When evaluated against WHO recommendations, 37 participants (44.0%, 95% CI: 33.2%–54.9%) exceeded the ideal free sugar intake threshold of $\geq 5\%$ of the total energy intake, whereas 14 participants (16.7%, 95% CI: 8.5%–24.8%) exceeded the acceptable upper limit of $\geq 10\%$. Among those exceeding the 10% threshold, the mean free sugar intake accounted for 14.1% of the total energy intake (range 10.2%–20.0%). The prevalence of excessive intake at the 5% level was similar between boys (43.5%) and girls (44.7%) ($p = 1.00$, Fisher's exact test).

Sources of free sugar

Across all dietary records, caregivers reported a total of 445 individual food items. The most frequently documented food group was confectioneries (group 15), accounting for 201 items (45.2%), followed by dairy products (group 13) with 117 items (26.3%), and fruits including 100% fruit juice (group 7) with 40 items (9.0%). As defined in this study's food group classification, "fruits" include items containing free sugars such as 100% fruit juice, whereas "dairy products" represent sweetened dairy foods. Intact fruits and plain unsweetened dairy products were not included in the calculation of free sugar.

Regarding free sugar contribution, confectioneries were the primary source (43.2% of the total intake), followed by fruits (27.3%), dairy products (23.3%), and beverages other than 100% fruit juice (group 16, 4.6%) (Figure 2). Figure 2 presents the percentage contribution of each food group to total free sugar intake across all dietary records. Notably, although fruits ranked third in frequency, they contributed disproportionately to free sugar in-

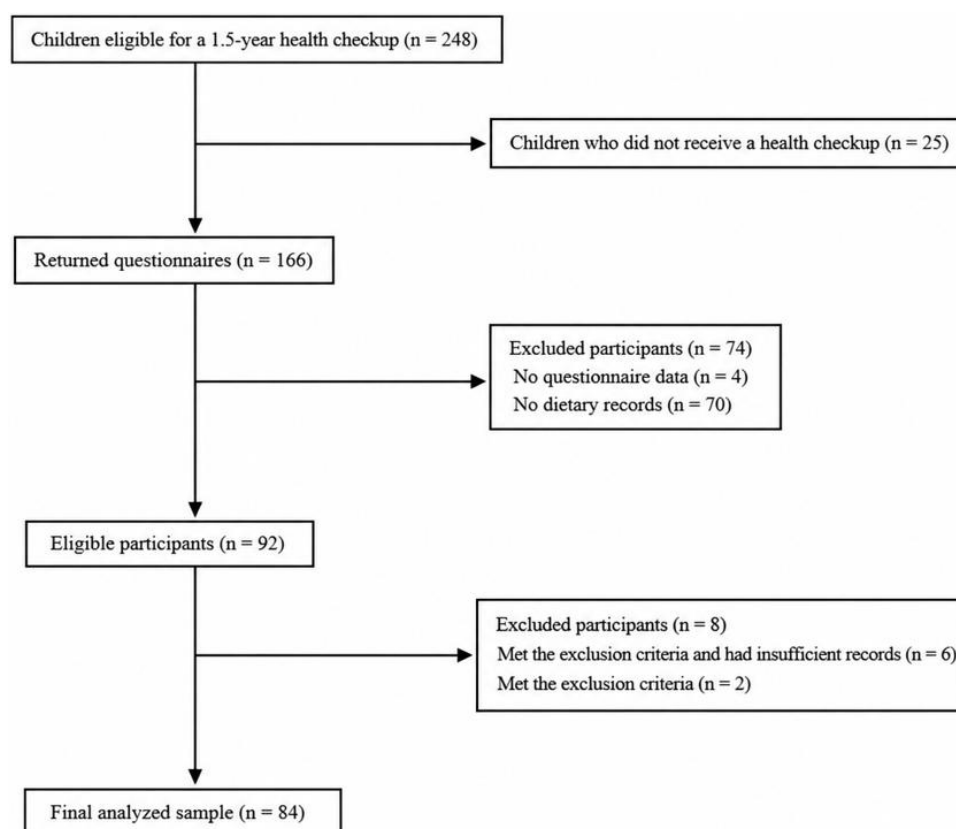


Figure 1. Participant flow diagram

Table 1. Participant characteristics (n = 84)

Variable	Total	≥5% of energy from free sugar	<5% of energy from free sugar	p-value
Participants, n (%)	84 (100)	37 (44.0)	47 (56.0)	—
Continuous variables				
Free sugar (g/day), mean (SD)	13.3 (10.5)	22.4 (9.3)	6.1 (3.5)	—
Free sugar (% of total energy intake), mean (SD)	5.7 (4.6)	9.7 (4.1)	2.6 (1.5)	—
Height (cm), mean (SD)	80.1 (3.0)	80.1 (3.4)	80.0 (2.8)	0.550
Weight (kg), mean (SD)	10.7 (1.1)	10.8 (1.2)	10.6 (1.1)	0.500
Percentage overweight (%), mean (SD)	3.9 (8.0)	4.9 (8.7)	3.1 (7.5)	0.470
Categorical variables				
Sex				1.000
Boys	46 (54.8)	20 (54.1)	26 (55.3)	
Girls	38 (45.2)	17 (45.9)	21 (44.7)	
Number of siblings				0.850
1	29 (34.5)	11 (30.1)	18 (40.0)	
2	29 (34.5)	14 (38.9)	15 (33.3)	
3	19 (22.6)	9 (25.0)	10 (22.2)	
4	4 (4.8)	2 (5.6)	2 (4.4)	
Sleep duration				0.690
<8 h	4 (4.8)	1 (2.8)	3 (6.4)	
8–11 h	65 (77.4)	28 (77.8)	37 (78.7)	
11–14 h	14 (16.7)	7 (19.4)	7 (14.9)	
≥14 h	0 (0)	0 (0)	0 (0)	
History of dental caries treatment				0.500
Yes	2 (2.4)	0 (0)	2 (4.3)	
No	81 (96.4)	36 (100)	45 (95.7)	
Attending kindergarten				1.000
Yes	71 (84.5)	31 (86.1)	40 (85.1)	
No	12 (14.3)	5 (13.9)	7 (14.9)	
Screen time				0.980
<30 min	16 (19.1)	7 (19.4)	9 (19.1)	
30 min–1 h	32 (38.1)	13 (36.1)	19 (40.4)	
1–3 h	31 (36.9)	14 (38.9)	17 (36.2)	
≥3 h	4 (4.8)	2 (5.6)	2 (4.3)	
Living with grandparents				0.750
Yes	11 (13.1)	4 (10.8)	7 (14.9)	
No	73 (86.9)	33 (89.2)	40 (85.1)	
Mother's age at childbirth				0.170
≤30 years	43 (51.2)	22 (61.1)	21 (45.7)	
≥31 years	39 (46.4)	14 (38.9)	25 (54.3)	
Parental smoking status				0.009
Neither parent smokes	42 (50.0)	14 (38.9)	28 (59.6)	
Only the father smokes	30 (35.7)	14 (38.9)	16 (34.0)	
Only the mother smokes	2 (2.4)	0 (0)	2 (4.3)	
Both parents smoke	9 (10.7)	8 (22.2)	1 (2.1)	
Occupation				0.240
Company employee	60 (71.4)	25 (69.4)	35 (74.5)	
Government worker	8 (9.5)	3 (8.3)	5 (10.6)	
Self-employed	10 (11.9)	7 (19.4)	3 (6.4)	
Part-time worker	3 (3.6)	0 (0)	3 (6.4)	
Unemployed	2 (2.4)	1 (2.8)	1 (2.1)	

Fisher's exact test was applied for categorical variables, and the Wilcoxon rank-sum test was used for continuous variables.

take, indicating a high sugar content per item (Figure 3).

The distribution of free sugar sources remained similar between participants with excessive (≥5% energy) and adequate (<5%) intake, suggesting that both groups primarily differed in terms of food quantity rather than source.

The distribution of food group contributions to total free sugar intake differed significantly between weekdays and Sundays in an exploratory chi-square test ($\chi^2 = 178$, $df = 4$, $p < 0.001$). Although confectioneries remained the top contributor on both days, dairy products ranked sec-

ond on weekdays (33.3%), whereas fruits including 100% juice ranked second on Sundays (32.7%) (Figure 4), indicating a higher relative contribution of fruit-based items on Sundays.

Factors associated with excessive free sugar intake

Univariate analysis revealed a significant association between parental smoking status and excessive free sugar intake (≥5% energy) ($p = 0.009$, Fisher's exact test). The prevalence of excessive intake was highest among children from households where both parents smoked

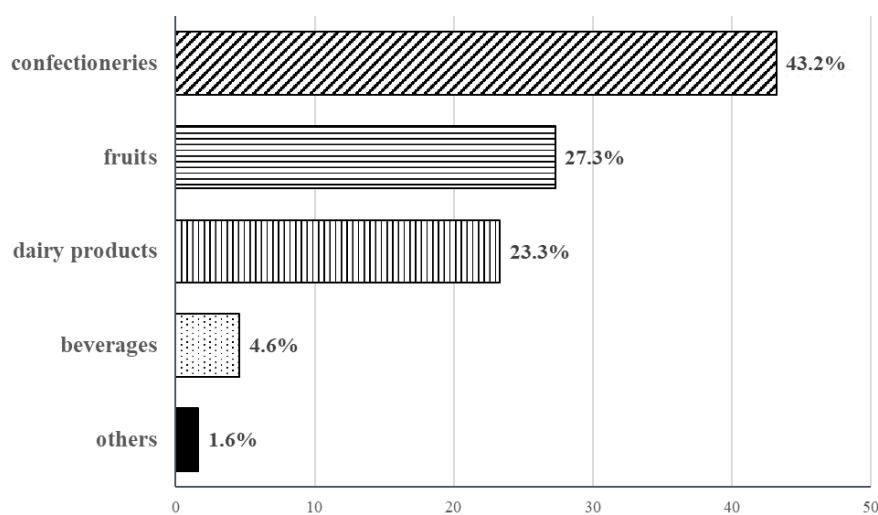


Figure 2. Percentage contribution of major food groups to total free sugar intake among Japanese infants aged 18–23 months

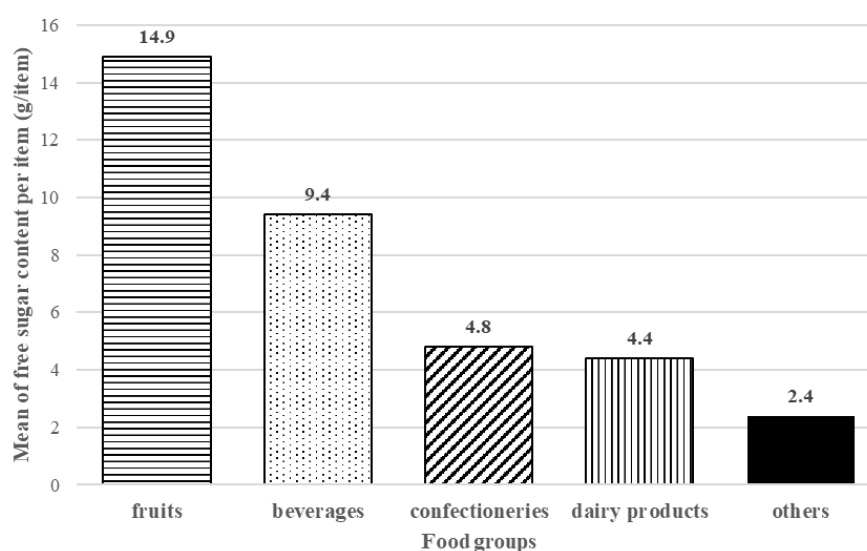


Figure 3. Mean free sugar content per consumed item for each major food group



Figure 4. Percentage contribution of food groups to total free sugar intake among Japanese infants aged 18–23 months on weekdays and Sundays.

(88.9%, 8 of 9), compared with nonsmoking households (33.3%, 14 of 42) and households with only paternal smoking (46.7%, 14 of 30). Other variables, including child sex, sleep duration, screen time, maternal age at delivery, number of siblings, and childcare attendance, were not significantly associated with excessive free sugar intake.

Multivariable logistic regression analysis adjusting for child sex, sleep duration, screen time, maternal age at delivery, and parental smoking status found that no variable was significantly associated with excessive free sugar intake (Table 2). For parental smoking, the adjusted odds ratio was 2.27 (95% CI: 0.89–5.78; $p = 0.086$). Although elevated, this association did not reach statistical significance and should be interpreted with caution because of the wide confidence interval.

Similar results were observed when excessive intake was defined using the $\geq 10\%$ energy threshold, although the small number of participants in this group ($n = 14$) might have limited the ability to detect significant differences (Table 3).

DISCUSSION

This cross-sectional study is the first to assess free sugar intake patterns among Japanese infants aged 18–23 months in a rural setting. Our key finding was that 44.0% of participants exceeded the WHO's ideal threshold for free sugar intake (5% of total energy intake), suggesting the importance of early dietary guidance targeting key free sugar sources—particularly 100% fruit juice and confectioneries—while ensuring that nutrient-dense foods such as fruits and dairy products are not discouraged. Previous studies in infants of the same age have shown mean intakes of 13.2%E in the US,²⁶ 10.4%E (29.3 g/day) in Australia,²⁵ and 9.0%E (25.1 g/day) in Ireland.²⁷ Herein, the mean daily free sugar intake was 13.3 g (5.7% of total energy), indicating that Japanese infants consumed less free sugar than their international counterparts; how-

ever, a considerable proportion exceeded the recommended intake levels during this critical developmental period.

This study has several methodological strengths. First, our study population was recruited through a municipal health checkup program targeting all children eligible for the 1.5-year checkup in Kama City, Fukuoka Prefecture. This approach may have reduced selection bias within the local population and provided data from a rural Japanese setting that has been underrepresented in previous research. Second, dietary intake was assessed using 2-day dietary records (one weekday and one Sunday), which is more robust than the single-day assessments commonly used in pediatric nutrition research.^{56,57} The inclusion of both weekdays and weekends reduced the potential for bias caused by temporal variation, particularly given the tendency for sugar intake to be higher on weekends than on weekdays.^{58,59} Third, the data collection spanned approximately 2 years, which may have helped reduce seasonal biases.^{60,61} Fourth, two trained registered dietitians applied the objective measurement methodology from Louie et al.^{33,43} In our assessments, the majority of foods were assessed up to Step 6, ensuring that most measurements were completed at the highest level of confidence. Finally, the exclusion criteria were established based on pediatric considerations, such as recent infection or low birth weight, which could affect feeding behavior. Supplemental analyses comparing the analytic sample with excluded participants showed no significant differences in core demographic characteristics, suggesting that substantial selection bias arising from participant exclusion was unlikely.

Our study identified confectioneries as the primary source of free sugar (43.2% of intake) followed by fruits including 100% juice (27.3%), providing important insights for targeted intervention strategies. Particularly noteworthy was the disproportionate contribution of 100% fruit juice, which represented more than one-quarter of the total free sugar intake despite comprising

Table 2. Multivariable logistic regression analysis to identify variables associated with free sugar intake $\geq 5\%$ of the total energy intake

Variable	Univariable OR (95% CI)	<i>p</i> -value	Multivariable OR (95% CI)	<i>p</i> -value
Child sex	1.05 (0.44–2.50)	0.908	1.26 (0.50–3.22)	0.622
Sleep duration	0.73 (0.23–2.29)	0.584	0.56 (0.16–1.96)	0.368
Screen time	0.98 (0.33–2.95)	0.973	0.86 (0.26–2.83)	0.801
Mother's age at childbirth	0.53 (0.22–1.30)	0.166	0.53 (0.21–1.34)	0.178
Parental smoking status	2.32 (0.95–5.63)	0.064	2.27 (0.89–5.78)	0.086

OR, odds ratio; CI, confidence interval.

Multivariable model adjusted for child sex, sleep duration, screen time, mother's age at childbirth, and parental smoking status.

Table 3. Multivariable logistic regression analysis to identify variables associated with free sugar intake $\geq 10\%$ of the total energy intake

Variable	Univariable OR (95% CI)	<i>p</i> -value	Multivariable OR (95% CI)	<i>p</i> -value
Child sex	1.78 (0.56–5.67)	0.331	1.83 (0.53–6.36)	0.339
Sleep duration	0.62 (0.15–2.63)	0.518	0.52 (0.11–2.41)	0.405
Screen time	0.76 (0.18–3.16)	0.706	0.61 (0.13–2.76)	0.521
Mother's age at childbirth	0.38 (0.11–1.32)	0.127	0.37 (0.10–1.39)	0.141
Parental smoking status	1.45 (0.46–4.64)	0.526	1.28 (0.37–4.41)	0.699

OR, odds ratio; CI, confidence interval.

Multivariable model adjusted for child sex, sleep duration, screen time, mother's age at childbirth, and parental smoking status.

only 9.0% of recorded food items. This finding suggests the notable contribution of 100% fruit juice to free sugar intake in this population and is in line with growing concerns regarding excessive fruit juice consumption in early childhood.⁶²⁻⁶⁴ Because our study focused on free sugar intake as defined by the WHO, intact fruit consumption itself was outside the scope of the assessment. Therefore, we could not determine whether the contribution of 100% fruit juice or fruit-based products reflected broader fruit consumption patterns or intake of these products independent of intact fruit consumption. This point should be considered when interpreting the dietary context of fruit-based sources of free sugar.

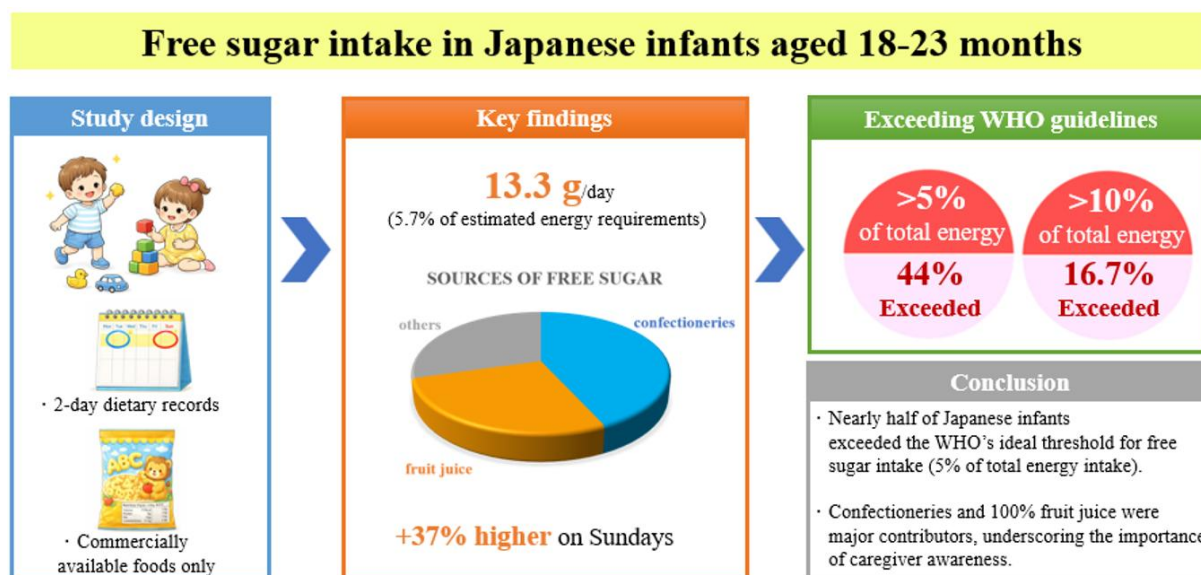
Our findings are consistent with the limited previous research conducted among Japanese children, particularly that by Fujiwara et al.,³³ which reported mean free sugar intakes of 6–7%E (17–18 g/day) in toddlers aged 18–35 months and 7–8%E (26–27 g/day) in preschool children aged 3–6 years, indicating consistently low intake levels across a broader age range. However, our study extends these findings by demonstrating concerning intake patterns even before the age of 2 years, earlier than previously documented in the Japanese population. The 16.7% and 44.0% prevalence of participants who exceeded the WHO 10% and 5% thresholds estimated using EERs-based energy references compares favorably to international data. In the United States, toddlers aged 12–23 months consumed on average 24 g/day (7.6%E),⁶⁵ and among children aged 2–5 years, 62.9% exceeded the WHO 10%E threshold.²⁶ In Canada, 80% of preschool children exceeded the 5%E threshold and 32% exceeded the 10%E threshold.⁶⁶⁻⁶⁸ In Australia, just over 50% of 2-year-olds consumed ≥ 10 %.²⁵ In Ireland, mean free sugar intake among 1–4-year-old children was 12%E (37.6 g/day), with average intakes of 13–14%E in 3- to 4-year-olds, indicating that the majority exceeded the 10%E threshold.²⁷ Although caution is warranted due to cross-national differences in food categorization, our finding that confectioneries were the largest source of free sugar aligns with reports from other high-income countries identifying similar sweet food categories (e.g., “sugar and sweets,” “bakery products”) as leading contributors.⁶⁶⁻⁶⁹ In contrast, the substantial contribution of 100% fruit juice in our study population may reflect specific dietary practices in rural Japanese communities, where fruit juice consumption might be perceived as supporting adequate fruit intake among young children. The notable variation in intake patterns between weekends and weekdays, as evidenced by a 37% higher consumption on weekends, has also been observed in other pediatric populations^{58,59} and may reflect changes in family routine and food availability. This temporal pattern suggests that intervention strategies may benefit from addressing both routine weekday feeding practices and special occasion or weekend dietary behaviors.

Several important considerations may account for the lack of significant associations between excessive free sugar intake and hypothesized risk factors, including sleep duration, screen time, and maternal age. First, the studied age group represents a period when parental control over dietary intake is nearly complete, potentially masking individual behavioral factors that become more

prominent in older children. This is supported by evidence showing strong dietary resemblance between parents and young children.⁷⁰ Second, the relatively homogeneous rural population may display limited variation in socioeconomic and lifestyle factors, reducing our ability to detect meaningful associations. This interpretation is supported by the household income distribution in our study region (Kama City), indicating that most households fell within the low-to-middle-income brackets and that the proportion of high-income households (≥ 10 million Japanese yen [JPY]) was substantially lower than that of the national average (2.9% vs. 15.3%).⁷¹ The observed association between parental smoking and excessive intake in the univariate analysis, which was attenuated in the multivariable models, warrants careful interpretation. Although this could represent a true association mediated by shared lifestyle behaviors or attitudes toward health recommendations,⁷² the attenuation after adjustment may also reflect confounding by measured or unmeasured factors, as well as limited statistical power. Potentially important confounding factors, such as parental educational attainment, household income, caregiver health literacy, and detailed feeding practices including breastfeeding history, were not collected and therefore could not be adjusted for in the analyses. These factors may influence both household food choices and children’s free sugar intake; therefore, residual confounding may remain, and the observed associations or lack of associations should be interpreted cautiously.

The small sample size also limits our study’s power to detect modest but clinically meaningful associations, raising the possibility of type II error.

Several limitations warrant consideration when interpreting these findings. First, this study only assessed the intake of commercially available foods and did not include free sugar from home-prepared foods or meals provided at daycare facilities, potentially underestimating the total intake of free sugar. However, given the age group of the participants studied, most of the free sugar sources are presumed to be commercial products.^{25,26,33,66,68,73} Because meals served at daycare facilities were not directly observed and often include commercial snacks, free sugar intake consumed during daycare may have been partially underreported, particularly on weekdays. Second, the EERs were used as a proxy for total energy intake, which was not directly measured. Although this method does not reflect individual energy intake, it has been commonly used in studies of toddlers where precise energy assessment is challenging.^{25,52,53} Therefore, the estimated %E should be interpreted as an approximate indicator of the relative contribution of free sugars to total energy needs, rather than a precise energy proportion. Third, reliance on published literature and recipe-based information for certain foods may introduce some degree of measurement error, although the use of a validated protocol and consistent evaluation by trained dietitians likely mitigated this issue. Fourth, although the dietary record form and self-administered questionnaire were specifically developed in Japanese and tailored for this population, they have not undergone validation. This may limit the reliability of certain responses, particularly regarding the estimation of portion sizes and recognition of commercial



Graphical abstract

food products and some self-reported measures. Fifth, potential reporting bias due to caregiver misreporting and social desirability bias cannot be ruled out; prior studies have documented underreporting of sweet foods, which may lead to underestimation of free sugar intake.⁷⁴ In addition, this observational cross-sectional study was not prospectively registered; therefore, the analyses of associated factors should be interpreted as exploratory. Although data collection was conducted continuously across approximately 2 years, seasonal variation in dietary intake was not separately adjusted for in the analyses. Thus, the possibility that seasonal differences in food availability or dietary habits influenced free sugar intake cannot be completely excluded. Although supplemental comparisons indicated no major differences between the analytic and excluded groups, some degree of self-selection bias cannot be entirely ruled out because demographic information was unavailable for a portion of excluded and nonresponding families. Moreover, no a priori power analysis was conducted, as this study used data from a municipal health checkup program that included all eligible children in the study area and was not originally designed for hypothesis testing; thus, the small sample size may have limited the power to detect modest but practically meaningful associations. In addition, analyses using the $\geq 10\%$ E threshold should be interpreted cautiously because the limited number of participants in this group may have resulted in unstable estimates and wide confidence intervals. The findings may also not be generalizable to younger infants, who may have different feeding patterns and dietary exposures, because this study included only children aged 18–23 months. Lastly, given that this study was conducted in a single rural area with a relatively small sample size, our results may not be generalizable to urban populations or other rural areas with different dietary environments and access to food products.⁷⁵

Conclusions

In this study of Japanese infants aged 18–23 months, 16.7% exceeded the WHO recommendation of <10% of energy from free sugar, and 44.0% exceeded the ideal

threshold of <5%. Confectioneries were the largest contributor to free sugar intake, followed by fruits including 100% juice, which accounted for more than one-quarter of total free sugar despite relatively infrequent consumption. No significant associations were observed between excessive intake and demographic or lifestyle characteristics. These findings highlight the substantial contribution of 100% fruit juice to free sugar intake in children under 2 years of age and provide foundational data on early-life dietary patterns. Future studies are needed to evaluate whether nutritional guidance targeting caregivers through early health checkups may support healthier dietary behaviors from infancy.

ACKNOWLEDGEMENTS

We are thankful to Ms. C. Koda and Ms. Y. Shigematsu, registered dietitians, for their contributions to the dietary data analysis, and Dr. H. Koga for statistical analysis support. We also appreciate the assistance of the public health staff in Kama City for their cooperation in participant recruitment and logistics.

DISCLOSURE ON THE USE OF AI AND AI-ASSISTED TECHNOLOGIES

AI-assisted technologies were used for the creation and visual refinement of the graphical abstract. All scientific content, data interpretation, and final decisions regarding the figure design were made by the authors.

CONFLICT OF INTEREST AND FUNDING DISCLOSURES

The authors declare no conflict of interest.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Afshin A, Forouzanfar MH, Reitsma MB, et al. Health effects of overweight and obesity in 195 countries over 25 years. *N Engl J Med*. 2017;377:13–27. doi:10.1056/NEJMoa1614362.
2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million

- children, adolescents, and adults. *Lancet*. 2017;390:2627-42. doi: 10.1016/S0140-6736(17)32129-3.
3. Fujiwara S, Harada K, Hagiya H, et al. Trends in childhood obesity in Japan: A nationwide observational study from 2012 to 2021. *Clin Obes*. 2024;14:e12636. doi:10.1111/cob.12636.
4. Boyer BP, Nelson JA, Holub SC. Childhood body mass index trajectories predicting cardiovascular risk in adolescence. *J Adolesc Health*. 2015;56:599-605. doi: 10.1016/j.jadohealth.2015.01.006.
5. Umer A, Kelley GA, Cottrell LE, Giacobbi P Jr, Innes KE, Lilly CL. Childhood obesity and adult cardiovascular disease risk factors: A systematic review with meta-analysis. *BMC Public Health*. 2017;17:683. doi: 10.1186/s12889-017-4691-z.
6. World Health Organization. Consideration of the evidence on childhood obesity for the commission on ending childhood obesity: Report of the ad hoc working group on science and evidence for ending childhood obesity. 2016 [cited 2026/1/21]; Available from: <https://iris.who.int/handle/10665/206549>
7. Matsushita Y, Yoshiike N, Kaneda F, Yoshita K, Takimoto H. Trends in childhood obesity in Japan over the last 25 years from the national nutrition survey. *Obes Res*. 2004;12:205-14. doi: 10.1038/oby.2004.27.
8. Vos MB, Kaar JL, Welsh JA, et al. Added sugars and cardiovascular disease risk in children: A scientific statement from the American Heart Association. *Circulation*. 2017;135:e1017-34. doi:10.1161/CIR.0000000000000439.
9. Yang Q, Zhang Z, Gregg EW, Flanders WD, Merritt R, Hu FB. Added sugar intake and cardiovascular diseases mortality among US adults. *JAMA Intern Med*. 2014;174:516-24. doi: 10.1001/jamainternmed.2013.13563.
10. Muth ND, Dietz WH, Magge SN, et al. Public policies to reduce sugary drink consumption in children and adolescents. *Pediatrics*. 2019;143:e20190282. doi:10.1542/peds.2019-0282.
11. World Health Organization. World Health Organization guideline: Sugars intake for adults and children. 2015 [cited 2026/1/21]; Available from: <https://www.who.int/publications/i/item/9789241549028>
12. US Department of Health and Human Services, US Department of Agriculture. Dietary Guidelines for Americans, 2020–2025. [cited 2026/1/21]; Available from: <https://www.dietaryguidelines.gov/>
13. Scientific Advisory Committee on Nutrition. SACN carbohydrates and health report. [cited 2026/1/21]; Available from: <https://www.gov.uk/government/publications/sacn-carbohydrates-and-health-report>
14. Government of Canada. Canada's dietary guidelines for health professionals and policy makers. [cited 2026/1/21]; Available from: <https://publications.gc.ca/site/eng/9.852216/publication.html>
15. Ernst JB, Arens-Azevedo U, Bosity-Westphal A, De Zwaan M, Egert S. Quantitative recommendation on sugar intake in Germany. *Ernahr Umsch*. 2019;66:26-34.
16. Hwang JY, Kim Y, Lee HS, et al. The development of resources for the application of the 2020 dietary reference intakes for Koreans. *J Nutr Health*. 2022;55:21-35. doi:10.4163/jnh.2022.55.1.21.
17. Yang YX, Wang XL, Leong PM, et al. New Chinese dietary guidelines: Healthy eating patterns and food-based dietary recommendations. *Asia Pac J Clin Nutr*. 2018;27:908-13. doi:10.6133/apjcn.072018.03.
18. Cooke L. The importance of exposure for healthy eating in childhood: A review. *J Hum Nutr Diet*. 2007;20:294-301. doi: 10.1111/j.1365-277X.2007.00804.x.
19. Birch LL, Doub AE. Learning to eat: Birth to age 2 y. *Am J Clin Nutr*. 2014;99:723S-728S. doi: 10.3945/ajcn.113.069047.
20. Mennella JA. Ontogeny of taste preferences: Basic biology and implications for health. *Am J Clin Nutr*. 2014;99:704S-711S. doi: 10.3945/ajcn.113.067694.
21. Park S, Pan L, Sherry B, Li R. The association of sugar-sweetened beverage intake during infancy with sugar-sweetened beverage intake at 6 years of age. *Pediatrics*. 2014;134:S56-62. doi: 10.1542/peds.2014-0646J.
22. Cusick SE, Georgieff MK. The role of nutrition in brain development: The golden opportunity of the "first 1000 days". *J Pediatr*. 2016;175:16-21. doi: 10.1016/j.jpeds.2016.05.013.
23. Beluska-Turkkan K, Korczak R, Hartell B, et al. Nutritional gaps and supplementation in the first 1000 days. *Nutrients*. 2019;11:2891. doi:10.3390/nu11122891.
24. Schwarzenberg SJ, Georgieff MK, Committee on Nutrition. Advocacy for improving nutrition in the first 1000 days to support childhood development and adult health. *Pediatrics*. 2018;141:e20173716. doi: 10.1542/peds.2017-3716.
25. Devenish G, Golley R, Mukhtar A, et al. Free sugars intake, sources and determinants of high consumption among Australian 2-year-olds in the SMILE cohort. *Nutrients*. 2019;11:161. doi:10.3390/nu11010161.
26. Wang Y, Guglielmo D, Welsh JA. Consumption of sugars, saturated fat, and sodium among US children from infancy through preschool age, NHANES 2009–2014. *Am J Clin Nutr*. 2018;108:868-77. doi: 10.1093/ajcn/nqy168.
27. Walton J, Kehoe L, McNulty BA, Nugent AP, Flynn A. Nutrient intakes and compliance with nutrient recommendations in children aged 1–4 years in Ireland. *J Hum Nutr Diet*. 2017;30:665-76. doi: 10.1111/jhn.12452.
28. Ministry of Health, Labour and Welfare, Japan. Dietary Reference Intakes for Japanese (2020) [in Japanese]. [cited 2026/1/21]; Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/kenkou/eiyou/syokuji_kijyun.html
29. Takeichi H, Taniguchi H, Fukinbara M, et al. Sugar intakes from snacks and beverages in Japanese children. *J Nutr Sci Vitaminol*. 2012;58:113-7. doi:10.3177/jnsv.58.113.
30. Shikanai S, Kouno Ry L, Takeichi H, et al. Sugar intake and body weight in Cambodian and Japanese children. *J Med Invest*. 2014;61:72-8. doi:10.2152/jmi.61.72.
31. Okubo H, Miyake Y, Sasaki S, Tanaka K, Hirota Y. Early sugar-sweetened beverage consumption frequency is associated with poor quality of later food and nutrient intake patterns among Japanese young children: The Osaka Maternal and Child Health Study. *Nutr Res*. 2016;36:594-602. doi: 10.1016/j.nutres.2016.01.008.
32. Saido M, Asakura K, Masayasu S, Sasaki S. Relationship between dietary sugar intake and dental caries among Japanese preschool children with relatively low sugar intake (Japan Nursery School SHOKUIKU Study): A nationwide cross-sectional study. *Matern Child Health J*. 2016;20:556-66. doi: 10.1007/s10995-015-1854-3.
33. Fujiwara A, Murakami K, Asakura K, et al. Estimation of starch and sugar intake in a Japanese population based on a newly developed food composition database. *Nutrients*. 2018;10:1474. doi:10.3390/nu10101474.
34. Fujiwara A, Murakami K, Asakura K, et al. Association of free sugar intake estimated using a newly-developed food composition database with lifestyles and parental characteristics among Japanese children aged 3–6 years:

- DONGuRI study. *J Epidemiol.* 2019;29:414–23. doi:10.2188/jea.JE20180036.
35. Fujiwara A, Okada E, Okada C, Matsumoto M, Takimoto H. Association between free sugar intake and nutrient dilution among Japanese children and adolescents: The 2016 National Health and Nutrition Survey, Japan. *Br J Nutr.* 2021;125:1394–404. doi: 10.1017/S0007114520003657.
 36. Fujiwara A, Okada E, Matsumoto M, Tajima R, Yuan X, Takimoto H. Association between food sources of free sugars and weight status among children and adolescents in Japan: The 2016 National Health and Nutrition Survey, Japan. *Nutrients.* 2022;14:3659. doi: 10.3390/nu14173659.
 37. Ministry of Health, Labour and Welfare. Health Japan 21 (the third term). [in Japanese]. [cited 2026/1/21]; Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/kenkou/kenkouinippon21_00006.html
 38. Migraine A, Nicklaus S, Parnet P, et al. Effect of preterm birth and birth weight on eating behavior at 2 y of age. *Am J Clin Nutr.* 2013;97:1270–7. doi:10.3945/ajcn.112.051151.
 39. Park J, Thoyre SM, Pados BF, Gregas M. Symptoms of feeding problems in preterm-born children at 6 months to 7 years old. *J Pediatr Gastroenterol Nutr.* 2019;68:416–21. doi: 10.1097/MPG.0000000000002229.
 40. Lanigan JA, Wells JC, Lawson MS, Lucas A. Validation of food diary method for assessment of dietary energy and macronutrient intake in infants and children aged 6–24 months. *Eur J Clin Nutr.* 2001;55:124–9. doi: 10.1038/sj.ejcn.1601128.
 41. Lanigan JA, Wells JCK, Lawson MS, Cole TJ, Lucas A. Number of days needed to assess energy and nutrient intake in infants and young children between 6 months and 2 years of age. *Eur J Clin Nutr.* 2004;58:745–50. doi: 10.1038/sj.ejcn.1601872.
 42. Consumer Affairs Agency, Government of Japan. Food labeling standards. [cited 2026/1/21]; Available from: https://www.caa.go.jp/en/policy/food_labeling/
 43. Louie JC, Moshtaghian H, Boylan S, et al. A systematic methodology to estimate added sugar content of foods. *Eur J Clin Nutr.* 2015;69:154–61. doi:10.1038/ejcn.2014.256.
 44. Ministry of Education, Culture, Sports, Science and Technology. Standard tables of food composition in Japan. 2020 [cited 2026/1/21]; Available from: https://www.mext.go.jp/a_menu/syokuhinseibun/mext_01110.html
 45. Food and Agriculture Organization of the United Nations. Carbohydrates in human nutrition: Report of a joint FAO/WHO expert consultation. [cited 2026/1/21]; Available from: <https://www.fao.org/4/w8079e/w8079e00.htm>
 46. Ministry of Health, Labour and Welfare. Survey on physical growth of infants: Overview. 2023 [cited 2026/1/21]; Available from: <https://www.mhlw.go.jp/toukei/list/73-22a.html>
 47. Paruthi S, Brooks LJ, D'Ambrosio C, et al. Consensus statement of the American Academy of Sleep Medicine on the recommended amount of sleep for healthy children: Methodology and discussion. *J Clin Sleep Med.* 2016;12:1549–61. doi:10.5664/jcsm.6288.
 48. World Health Organization. Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age. 2019 [cited 2026/1/21]; Available from: <https://apps.who.int/iris/handle/10665/311664>
 49. Council on Communications and Media. Media and young minds. *Pediatrics.* 2016;138:e20162591. doi: 10.1542/peds.2016-2591.
 50. Canadian Paediatric Society, Digital Health Task Force. Screen time and young children: Promoting health and development in a digital world. *Paediatr Child Health.* 2017;22:461–77. doi: 10.1093/pch/pxx123.
 51. Ministry of Health, Labour and Welfare, Japan. Preliminary report on the annual total of vital statistics for 2022 [monthly report]. [cited 2026/1/21]; Available from: <https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nen gai22/index.html>
 52. Devenish G, Ytterstad E, Begley A, Do L, Scott J. Intake, sources, and determinants of free sugars intake in Australian children aged 12–14 months. *Matern Child Nutr.* 2019;15:e12692. doi: 10.1111/mcn.12692.
 53. Murakami K, Livingstone MBE. Prevalence and characteristics of misreporting of energy intake in US children and adolescents: NHANES 2003–2012. *Br J Nutr.* 2016;115:294–304. doi: 10.1017/S0007114515004304.
 54. Ríos-Hernández A, Gilchrist C, Chelimo C, et al. The relationship between diet and sleep in 2-y-old children: Results from Growing Up in New Zealand. *Nutrition.* 2022;95:111560. doi:10.1016/j.nut.2021.111560.
 55. Pawellek I, Grote V, Theurich M, et al. Factors associated with sugar intake and sugar sources in European children from 1 to 8 years of age. *Eur J Clin Nutr.* 2017;71:25–32. doi:10.1038/ejcn.2016.206.
 56. Burrows TL, Martin RJ, Collins CE. A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *J Am Diet Assoc.* 2010;110:1501–10. doi: 10.1016/j.jada.2010.07.008.
 57. Liu J, Micha R, Li Y, Mozaffarian D. Trends in food sources and diet quality among US children and adults, 2003–2018. *JAMA Netw Open.* 2021;4:e215262. doi: 10.1001/jamanetworkopen.2021.5262.
 58. Rothausen BW, Matthiessen J, Hoppe C, Brockhoff PB, Andersen LF, Tetens I. Differences in Danish children's diet quality on weekdays v. weekend days. *Public Health Nutr.* 2012;15:1653–60. doi: 10.1017/S1368980012002674.
 59. Svensson A, Larsson C, Eiben G, et al. European children's sugar intake on weekdays versus weekends: The IDEFICS study. *Eur J Clin Nutr.* 2014;68:822–8. doi:10.1038/ejcn.2014.87.
 60. Sasaki S, Takahashi T, Itoi Y, et al. Food and nutrient intakes assessed with dietary records for the validation study of a self-administered food frequency questionnaire in JPHC Study Cohort I. *J Epidemiol.* 2003;13:S23–50. doi:10.2188/jea.13.1sup_23.
 61. Tani Y, Asakura K, Sasaki S, et al. The influence of season and air temperature on water intake by food groups in a sample of free-living Japanese adults. *Eur J Clin Nutr.* 2015;69:907–13. doi:10.1038/ejcn.2014.290.
 62. Heyman MB, Abrams SA, Heitlinger LA, et al. Fruit juice in infants, children, and adolescents: Current recommendations. *Pediatrics.* 2017;139:e20170967. doi:10.1542/peds.2017-0967.
 63. Nguyen M, Jarvis SE, Chiavaroli L, et al. Consumption of 100% fruit juice and body weight in children and adults: A systematic review and meta-analysis. *JAMA Pediatr.* 2024;178:237–46. doi:10.1001/jamapediatrics.2023.6124.
 64. Robinson SL, Sundaram R, Putnick DL, et al. Predictors of age at juice introduction and associations with subsequent beverage intake in early and middle childhood. *J Nutr.* 2021;151:3516–23. doi:10.1093/jn/nxab260.
 65. Herrick KA, Fryar CD, Hamner HC, Park S, Ogden CL. Added sugars intake among US infants and toddlers. *J Acad Nutr Diet.* 2020;120:23–32. doi: 10.1016/j.jand.2019.09.007.
 66. Mahajan A, Yu J, Hogan JL, et al. Dietary sugar intake among preschool-aged children: A cross-sectional study.

- CMAJ Open. 2021;9:E855–63. doi:10.9778/cmajo.20200178.
67. Rana H, Mallet MC, Gonzalez A, Verreault MF, St-Pierre S. Free sugars consumption in Canada. *Nutrients*. 2021;13:1471. doi: 10.3390/nu13051471.
 68. Yu J, Mahajan A, Darlington G, et al. Free sugar intake from snacks and beverages in Canadian preschool- and toddler-aged children: A cross-sectional study. *BMC Nutr*. 2023;9:44. doi:10.1186/s40795-023-00702-3.
 69. Louie JCY, Moshtaghian H, Rangan AM, Flood VM, Gill TP. Intake and sources of added sugars among Australian children and adolescents. *Eur J Nutr*. 2016;55:2347–55. doi: 10.1007/s00394-015-1041-8.
 70. Vepsäläinen H, Nevalainen J, Fogelholm M, et al. Like parent, like child? Dietary resemblance in families. *Int J Behav Nutr Phys Act*. 2018;15:62. doi:10.1186/s12966-018-0693-1.
 71. Kama City. Child life status survey report. [cited 2026/1/21]; Available from: <https://www.city.kama.lg.jp/soshiki/14/35222.html>
 72. Gui Z, Huang S, Chen Y, et al. Association between sugar-sweetened beverage consumption and executive function in children. *Nutrients*. 2021;13:4563. doi:10.3390/nu13124563.
 73. Redruello-Requejo M, Samaniego-Vaesken ML, Partearroyo T, et al. Dietary intake of individual (intrinsic and added) sugars and food sources from Spanish children aged one to <10 years: Results from the EsNuPI Study. *Nutrients*. 2022;14:1667. doi:10.3390/nu14081667.
 74. EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA), Turck D, Bohn T, Castenmiller J et al. Tolerable upper intake level for dietary sugars. *EFSA J*. 2022;20:e07074. doi: 10.2903/j.efsa.2022.7074.
 75. Wende ME, Meyer MRU, Abildso CG, Davis K, Kaczynski AT. Urban-rural disparities in childhood obesogenic environments in the United States: Application of differing rural definitions. *J Rural Health*. 2023;39:121–35. doi:10.1111/jrh.12677.