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Original article

Development and Validation of a Simplified Dietary Self-Monitoring Method based on the Number of Food Items Consumed per Meal

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Summary

This study evaluated the validity and usefulness of a dietary self-monitoring method based on counting the number of food items consumed per meal. In 2005, a 3-day dietary record was collected during health checkups for residents of T-city, Nagano, Japan. Using the dietary values, including the estimated average requirement, recommended dietary allowance for micronutrients for which deficiencies are common, and estimated energy requirement, the number of food items consumed per meal was calculated. In 2007, during the same health checkups, the number of food items consumed per meal was recorded to assess the usefulness of the method by comparing counts reported by participants and researchers. The analysis indicated that 10–12 food items per meal for men and 9–10 for women could meet the micronutrient requirements while maintaining energy intake within the range that does not exceed the estimated energy requirement for individuals with medium levels of physical activity. A high number of food items consumed was also associated with a healthier dietary pattern. Moreover, participant-reported counts showed a strong positive correlation with researcher counts ($r = 0.709$, $p = 0.01$), with no significant difference between them. These findings support the validity and applicability of this self-monitoring approach.

Introduction

Adequate energy and nutrient intake is essential for maintaining and promoting health. In Japan, the Dietary Reference Intakes (DRIs) provide intake standards based on sex and age[1)]. However, for individuals without specialized knowledge, such as registered dietitians, it remains challenging to assess whether their dietary habits meet these standards.

A comparison between the Estimated Average Requirement (EAR) from the 2025 DRIs and the results of the 2023 National Health and Nutrition Survey in Japan[2)] indicates that the median intake of several vitamins, including vitamins A, B_2, B_6, C, calcium, magnesium, and iron was lower than the EAR. Thus, insufficient intake of these key nutrients remains a public health concern. To address this issue, it is necessary to develop simple methods that allow individuals to monitor their own dietary intake.

One such approach is the concept of "30 food items per day." This concept was introduced in 1985 by the Ministry of Health and Welfare (now the Ministry of Health, Labor and Welfare) as a form of self-monitoring aimed at improving nutrient intake[3)]. However, this method was later criticized for potentially leading to excessive energy intake as people tried to increase food variety, and it has not been recommended since 2000.

Although "30 food items per day" is no longer recommended, despite its limitations, counting the number of different food items consumed remains a simple and accessible method of dietary self-monitoring. It can be especially useful for children, the elderly, and individuals who are not responsible for meal preparation. Recent studies have examined more practical targets for food item diversity. Koyama et al.[4)] suggested that consuming 25–28 food items per day may be sufficient for achieving adequate energy and nutrient intake, especially when meals include a balance of "shushoku (staple food)," "shusai (main dish)," and "fukusai (side dish)"[5)]. Other studies have proposed similar targets: Seki et al.[6)] and Kasamatsu et al.[7)] recom-

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mended approximately 20–24 and 25 items per day, respectively, based on calcium adequacy.

However, these methods are associated with several practical issues. First, foods eaten multiple times a day are still counted as one item. For example, eating seasonal foods at every meal would still count as a single food item.

Second, tracking food item counts across an entire day can be burdensome, especially for people who do not prepare their own meals.

To overcome these challenges, we aimed to develop a simplified dietary self-monitoring method that focuses on the number of food items consumed per meal, allowing users to evaluate their dietary variety at each meal without considering the overlaps throughout the day.

Therefore, in this study, we aimed to evaluate the validity of a self-monitoring method based on food item counts per meal using data from a previous dietary survey (Study 1). In addition, we aimed to examine its usefulness for the general public, by comparing food item counts recorded by both participants and researchers (Study 2).

Materials and Methods

Study 1

A 3-day weighed dietary record (DR) survey was conducted during health checkups for residents of T-city, Nagano Prefecture, Japan, between July and October 2005.

A total of 2,186 individuals participated in the health checkups, from which 340 participants were selected through stratified random sampling based on sex and age. The exclusion criteria included individuals who were ≤29 or ≥75 years (*n*17), individuals who declined participation (*n*185), and individuals who were classified as dropouts due to invalid dietary record (DR) responses (*n*16). After applying these criteria, 122 participants, aged 30–74 years, were included in the final analysis.

Participants recorded dietary intake over three consecutive days between July and October 2005. The following items were recorded: (i) dish names, (ii) food names, and (iii) measured weight or portion size. Grains, meats, fish and shellfish, and soy products were recorded using the food-weighing method. For the other food groups, including dairy products, eggs, nuts and seeds, fruits, vegetables, mushrooms, potatoes, seaweeds, beverages, and confectioneries, the most appropriate item was selected from the provided list. Dietitians reviewed the DR to check for completeness and added any missing information, as necessary.

The number of consumed food items was calculated as the three-day mean. The number of consumed food items in a day was counted excluding duplicates or more between meals in the same day. Three-day counts of consumed food items corrected for overlap in a day were divided by three to obtain the number of food items consumed "per day". For each meal, the number of consumed food items was counted excluding duplicates or more within meals. Three-day counts of consumed food items corrected for overlap in each meal were divided by nine (three meals per day for over three days) to obtain the number of consumed food items "per meal". For example, if tofu was consumed in miso soup at breakfast and in a salad at dinner on the same day, it was counted once at each meal (breakfast and dinner, total of two) in the "per meal" calculation, but only once in the "per day" Calculation. Energy and nutrient intakes were calculated using the nutritional calculation software "Nutrition Plus" (Kenpakusha, Japan), based on the 2020 edition (8th revision) of the Standard Tables of Food Composition in Japan (STFCJ)[8]. These calculations prioritized the use of adjustments for nutrient losses during cooking[9–11].

Study 2

A survey of the number of food items consumed per meal was conducted during health checkups for residents in the same area as Study 1 in 2007. A total of 1,262 individuals provided valid responses. Participants recorded the names of dishes and foods consumed at each meal (breakfast, lunch, dinner, and snacks) and then scored the number of food items consumed per meal. Researchers independently calculated the number of food items consumed per meal based on the DR by participants using the same method as in Study 1, to allow comparison between participant-reported and researcher-calculated values.

Data Analysis

Data normality was analyzed using the Shapiro–Wilk test. The relationship between the number of food items consumed per meal and energy and nutrient intake was analyzed using simple linear regression. The required number of consumed food items to meet the estimated energy requirement (EER) and to achieve the EAR and the recommended dietary allowance (RDA) for micronutrients with a high prevalence of deficiency in the population was estimated using regression equations for each micronutrient. In this study, the following were defined as "deficient micronutrients" based on the 2023 National Health and Nutrition Survey in Japan, in which median intakes were below the 2025 DRIs EAR: vitamin A, vitamin B_2, vitamin B_6, vitamin C, calcium, magnesium, and iron. Correlation analyses between the number of food items consumed and the intake of each food group, as well as the correlation between the number of food items reported by the participants and researchers, were analyzed using Spearman's rank correlation coefficient. The paired t-test was used to compare mean food item counts between the participants and researchers. All analyses were conducted using IBM SPSS Statistics version 29.0, and results were considered statistically significant at *p*-values < 0.05.

Ethics

This study was conducted in accordance with the Ethical Guidelines for Medical and Health Research Involving Human Subjects, and approved by the Doshisha Women's College of Liberal Arts Research Ethics Review Committee regarding Human Subjects (approval number: 3). All data were anonymized and statistically analyzed.

Table 1. Basic characteristics of the participants

	All	Men	Women
n	122	46	76
Age	59.5 ± 9.5 (30, 74)	63.9 ± 5.9 (40, 74)	56.9 ± 10.3 (30, 73)
Body height (cm)	158.8 ± 8.0 (141.0, 177.0)	166.0 ± 5.5 (156.0, 177.0)	154.5 ± 6.0 (141.0, 170.0)
Body weight (kg)	58.5 ± 9.1 (39.0, 89.0)	64.6 ± 8.3 (50.0, 89.0)	54.9 ± 7.5 (39.0, 78.0)
BMI (kg/m^2)	23.1 ± 2.9 (15.4, 31.2)	23.4 ± 2.6 (17.8, 31.2)	23.0 ± 3.1 (15.4, 30.3)

Mean ± standard deviation (minimum, Maximum)

Results

Study 1

This analysis included 46 men aged 63.9 ± 5.9 years, and 76 women aged 56.9 ± 10.3 years (Table 1).

There was a positive correlation between the number of food items consumed per meal and both energy and deficient micronutrient intake (Fig. 1).

The estimated number of food items per meal required to meet the EAR for all deficient micronutrients was 9.9 for men aged 30–49, 9.4 for men aged 50–64, 9.1 for men aged 65–74, and 8.7 for women (Table 2–1). The maximum number of food items consumed per meal that did not exceed the EER was 12.2 for men aged 30–49, 11.9 for men aged 50–64, 10.9 for men aged 65–74 years, 9.9 for women aged 30–49, 9.6 for women aged 50–64, and 9.3 for women aged 65–74 (Table 2–1). The estimated number of food items per meal required to meet the RDA is also shown in Table 2-2.

Table 3 presents the correlation between the number of food items consumed and the intake of each food group. Significant positive correlations were observed with vege-

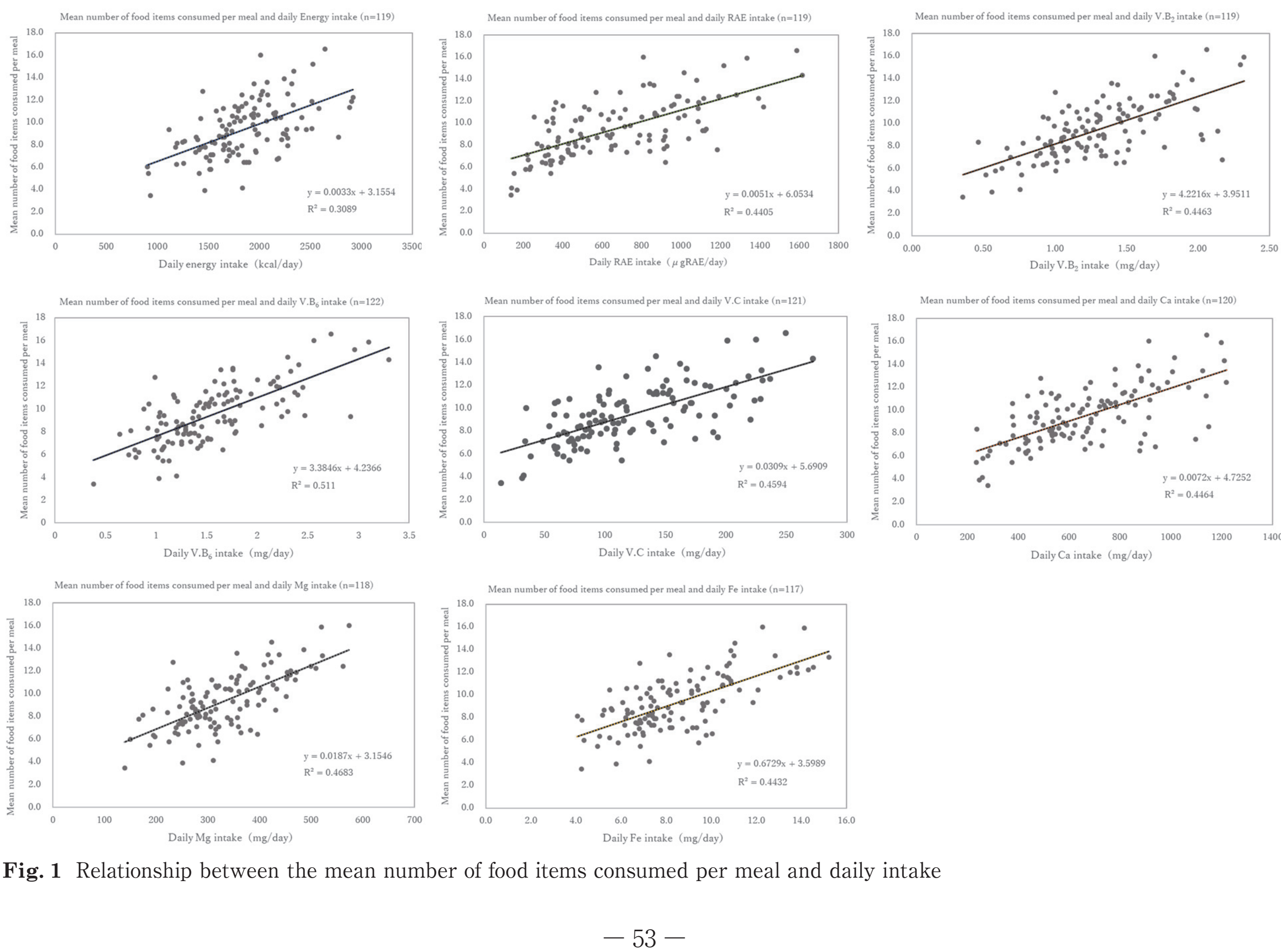

Fig. 1 Relationship between the mean number of food items consumed per meal and daily intake

Table 2-1. The number of food items consumed per meal for the EER and the EAR

Sex	Age	Energy		V.A		$V.B_2$		$V.B_6$		V.C		Ca		Mg		Fe		Max
		*n*119		*n*119		*n*119		*n*122		*n*121		*n*120		*n*118		*n*117		
		EER (kcal/d)	Number of consumed food items	EAR (μgRAE/d)	Number of consumed food items	EAR (mg/d)	Number of consumed food items	EAR (mg/d)	Number of consumed food items	EAR (mg/d)	Number of consumed food items	EAR (mg/d)	Number of consumed food items	EAR (mg/d)	Number of consumed food items	EAR (mg/d)	Number of consumed food items	
Men	30-49	2750	**12.2**	650	9.4	1.4	9.9[a]					650	9.4	320	9.1	6.0	7.6	**9.9**
	50-64	2650	**11.9**	650	9.4[a]	1.3	9.4[a]	1.2	8.3	80	8.2	600	9.0	310	9.0	6.0	7.6	**9.4**
	65-74	2350	**10.9**	600	9.1[a]	1.2	9.0					600	9.0	290	8.6	5.5	7.3	**9.1**
Women	30-49	2050	**9.9**			1.0	8.2									7.5	8.6	
	50-64	1950	**9.6**	500	8.6	1.0	8.2	1.0	7.6	80	8.2	550	8.7[a]	240	7.6	7.5	8.6	**8.7**
	65-74	1850	**9.3**			0.9	7.8									5.0[b]	7.0	

EER; Estimated Energy Requirement. EAR; Estimated Average Requirement. Nutrients below the EAR in the National Health and Nutrition Survey in Japan 2023 results.
The EER for individuals with medium levels of physical activity.
[a] Maximum number of food items consumed by each age group.
[b] Not menstruating

Table 2-2. The number of food items consumed per meal for the RDA

Sex	Age	V.A		$V.B_2$		$V.B_6$		V.C		Ca		Mg		Fe		Max
		*n*119		*n*119		*n*122		*n*121		*n*120		*n*118		*n*117		
		RDA (μgRAE/d)	Number of consumed food items	RDA (mg/d)	Number of consumed food items	RDA (mg/d)	Number of consumed food items	RDA (mg/d)	Number of consumed food items	RDA (mg/d)	Number of consumed food items	RDA (mg/d)	Number of consumed food items	RDA (mg/d)	Number of consumed food items	
Men	30-49	900	10.6	1.7	11.1[a]	1.5	9.3					380	10.3	7.5	8.6	**11.1**
	50-64	900	10.6	1.6	10.7[a]	1.5	9.3	100	8.8	750	10.1	370	10.1	7.0	8.3	**10.7**
	65-74	850	10.4[a]	1.4	9.9	1.4	9.0					350	9.7	7.0	8.3	**10.4**
Women	30-49			1.2	9.0							290	8.6	10.5	10.7[a]	**10.7**
	50-64	700	9.4[a]	1.2	9.0	1.2	8.3	100	8.8	650	9.4[a]	290	8.6	10.5	10.7[a]	**10.7**
	65-74			1.1	8.6							280	8.4	6.0[b]	7.6	**9.4**

RDA; Recommended Dietary Allowance. Nutrients below the EAR in the National Health and Nutrition Survey in Japan 2023 results.
[a] Maximum number of food items consumed by each age group.
[b] Not menstruating

Table 3. Spearman correlation coefficients between the intake(g) of each food group and the number of food items consumed per day or per meal

food group	All (*n*122)			Men (*n*46)			Women (*n*76)		
	Median (25%, 75%), g	per day	per meal	Median (25%, 75%), g	per day	per meal	Median (25%, 75%), g	per day	per meal
Grains	251.5 (207.0, 303.3)	-0.105	-0.013	303.3 (238.7, 367.3)	-0.115	-0.040	230.2 (192.6-266.0)	0.040	0.071*
Potatoes	66.7 (33.3, 99.6)	0.250**	0.400***	69.4 (33.5, 110.4)	0.536***	0.693***	60.3 (28.1-91.3)	0.098	0.205
Nuts and seeds	1.0 (0.0, 4.0)	0.277**	0.217*	0.5 (0.0, 2.5)	0.290	0.215	1.4 (0.0-4.5)	0.241*	0.218
Vegetables	425.6 (326.2, 573.4)	0.524***	0.602***	434.8 (291.0, 727.5)	0.623***a	0.702***	418.1 (336.6-544.5)	0.510***	0.529***
Green and yellow vegetables	160.1 (111.0, 250.5)	0.560***	0.620***	190.2 (106.4, 283.3)	0.592***	0.688***	148.1 (111.7-226.2)	0.586***	0.574***
Other vegetables	267.3 (182.0, 360.6)	0.429***	0.506***	263.5 (180.8, 384.6)	0.561***	0.630***	267.3 (182.0-345.7)	0.374***	0.421***
Fruits	128.3 (63.3, 201.6)	0.528***	0.491***	83.3 (31.3, 188.5)	0.722***	0.693***	145.0 (85.4-210.5)	0.383***	0.350**
Mushroom	10.3 (3.6, 24.5)	0.516***	0.443***	5.0 (0.0, 20.0)	0.463***	0.430**	15.0 (6.9-25.0)	0.477***	0.410***
Seaweeds	12.6 (6.7, 22.0)	0.181*	0.217*	13.2 (7.3, 22.2)	0.220	0.259	11.7 (6.7-22.1)	0.182	0.184
Legumes	80.7 (44.9, 118.8)	0.186*	0.180*	83.3 (52.2, 125.8)	0.140	0.128	71.0 (42.1-114.5)	0.225	0.205
Fish and shellfish	91.3 (66.3, 144.1)	0.269**	0.349***	112.3 (68.5, 165.2)	0.215	0.335*	86.2 (60.8-136.9)	0.375***	0.381***
Meats	46.7 (23.3, 75.5)	0.326***	0.321***	49.3 (30.4, 80.0)	0.322*	0.305*	46.7 (22.1-73.3)	0.357**	0.349**
Eggs	35.5 (20.8, 51.7)	0.142	0.089	37.4 (17.8, 50.5)	0.175	0.181	35.0 (20.8-53.4)	0.137	0.017
Dairy products	200.0 (113.3, 278.5)	0.398***	0.367***	200.0 (38.3-277.3)	0.498***	0.481***	220.6 (138.3-280.0)	0.334**	0.330**
Confectionaries	16.7 (0.0, 33.3)	0.262**	0.261**	0.0 (0.0-33.3)	0.290	0.325*	17.8 (2.1-35.8)	0.234*	0.208

Values are Spearman correlation coefficients (*p<0.05, **p<0.01, ***p<0.001)

tables (green and yellow, and others), fruits, and mushrooms. In men, tuber intake showed a significant positive correlation with the number of consumed food items.

Study 2

Table 4 presents the basic characteristics of the participants and the comparison between participant- and researcher-estimated food item scores. This analysis included 433 men aged 64.4 ± 13.2 years and 829 women aged

Table 4. Association between the number of consumed food items scored by participants and researchers

Sex	Age	n	Mean ± SD		p ^{a}
			researcher	participants	
All		1262	8.75 ± 2.59	8.67 ± 2.94	0.237
Men	-39	36	6.52 ± 0.40	6.69 ± 0.41	0.469
	40-59	70	7.32 ± 0.30	6.94 ± 0.35	0.152
	60-69	155	8.63 ± 0.19	8.63 ± 0.23	1.000
	70-	172	8.89 ± 0.19	9.52 ± 0.22	0.001
Women	-39	140	7.45 ± 0.21	7.40 ± 0.23	0.721
	40-59	251	8.77 ± 0.15	8.37 ± 0.15	<0.001
	60-69	247	9.77 ± 0.17	9.22 ± 0.18	<0.001
	70-	191	9.24 ± 0.18	9.59 ± 0.24	0.081

Mean ± standard deviation (SD) for age: All, 59.7 ± 14.6; Men, 64.4 ± 13.2; Women, 57.3 ± 14.7.
^{a} p-values for the t-test.

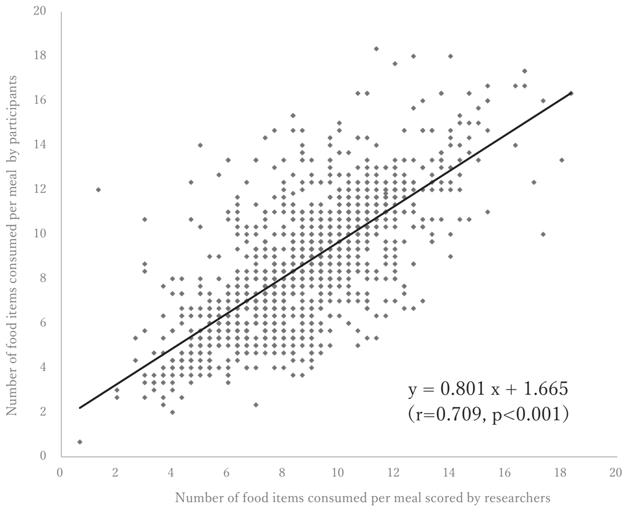

Fig. 2 Association between the number of consumed food items by participants and researchers (n1262)

57.3 ± 14.7 years.

There was no significant difference between the number of food items consumed per meal reported by participants and those calculated by researchers. However, when stratified by sex and age: men aged ≥70 years had significantly lower participant scores than researcher scores (p=0.001), and women aged 40–69 years had significantly higher participant scores than researcher scores ($p < 0.001$).

A significant positive correlation was observed between participant and researcher scores (r=0.709, $p < 0.001$) (Fig. 2).

Discussion

In this study, we found that the number of food items consumed per meal to meet the EAR for deficient micronutrients was 9.1–9.9 for men and 8.7 for women. In addition, the number of food items consumed per meal to meet the RDA was 10.4–11.1 items for men and 9.4–10.7 items for women. These results suggest the number of food items consumed per meal may serve as a reference for future studies and dietary self-monitoring approaches.

A significant positive correlation was observed between the number of food items and the intake of vegetables (green, yellow, and others), fruits, and mushrooms, and for men tuber intake as well. These results indicate that a higher number of consumed food items tends is associated with higher vegetable, fruit, and mushroom intake. Seki et al.[6] reported that the intake of all food groups tended to increase as the number of consumed food items increases. Similarly, Kasamatsu et al.[7] observed increases in the intake of potatoes, confectioneries, fats and oils, legumes, fruits, vegetables, seaweed, fish and shellfish, meat, eggs, and dairy products. Koyama et al.[4] also reported that as the number of consumed food items increased, in the intake of “shushoku” decreased, while the intake of “shusai” and “fukusai” increased. Given that the main components of “shusai” and “fukusai” include vegetables, fruits, mushrooms, and potatoe[12], these results suggest that increasing the number of food items encourages more balanced meals. Higher vegetable and fruit intake has well-known health benefits. Health Japan 21[13] recommends a daily intake of ≥350 g of vegetables (based on fiber and potassium content) and around 200 g per day of fruits to reduce the risk of developing hypertension, obesity, and type 2 diabetes. Thus, increasing the number of food items consumed per meal contributes to a higher intake of “shusai” and “fukusai”, leading to a healthier diet.

There was a significant positive correlation between participant and researcher scores. Furthermore, no significant difference was observed in the number of food items consumed per meal when assessed by participants compared to researchers. These results confirm the validity of dietary self-monitoring using the number of food items per meal. The high correlation between participant and researcher scores suggests that individuals can accurately assess their own food variety. This method is also practical for use in nutrition education, as it allows each meal to be evaluated independently. However, we observed sex and age differences: older men may have underestimated intake due to lower dietary interest or poor food recognition and middle-aged women may have overestimated intake by excluding small items, perhaps due to cooking knowledge or perception that they “don't count”. These findings highlight the need to tailor dietary tools and education based on demographic differences.

This study has several limitations. First, the study was conducted in T-city, Nagano, Japan, which is a rural area with high vegetable and fruit production[14]. Nagano has been reported to have the highest vegetable intake among men and women in Japan[15]. Thus, the study population offers limited generalizability. Additionally, it is associated with age bias: the sample skewed older, and the 2023 National Health and Nutrition Survey indicates that elderly people tend to have a higher vegetable intake[2]. Based on these points, overall, the participants in this study were likely to have a higher-than-average vegetable intake. Further studies considering regional differences and age groups are necessary. Furthermore, as this study used data from 2005 and 2007, it does not reflect current dietary habits influenced by recent changes in the food environment and rising food prices. A comparison of the 2005[16] and 2023 National Health and Nutrition Surveys revealed differences in dietary habits, particularly in the mean intake of fruits, fish, shellfish, and meat. Therefore, it is necessary to interpret the results of this study with caution and conduct further research using more recent data.

Despite these limitations, this study is the first to examine the validity and practical use of a dietary self-monitoring method based on the number of food items consumed per meal, utilizing the latest version of the STFCJ, and considering nutrient loss during cooking.

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Conflicts of Interest

The authors have no conflicts of interest to declare.

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