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Original Research

Science electives in high school will improve nutrition knowledge but not enough to make accurate decisions

Takahiro Mitsui [1§], **Susumu Yamamoto** [2], **and Morito Endo** [3]

[1]Department of Home Economics, Faculty of Education, Iwate University, Iwate 020-8550, Japan
[2]Graduate School of Teacher Education, Iwate University, Iwate 020-8550, Japan
[3]Faculty of Human Health Science, Hachinohe Gakuin University, Aomori 031-8588, Japan

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[§]Corresponding Author:
Takahiro Mitsui
Department of Home Economics, Faculty of Education, Iwate University, 3-18-33 Ueda, Morioka, Iwate 020-8550, Japan.
Tel. +81-19-621-6649
Fax. +81-19-621-6600
Email. mitsui@iwate-u.ac.jp

ORCID iDs
Takahiro Mitsui
https://orcid.org/0000-0002-1388-252X
Susumu Yamamoto
https://orcid.org/0000-0002-2462-2459
Morito Endo
https://orcid.org/0000-0001-5774-4826

Conflict of Interest
The authors declare no potential conflicts of interests.

ABSTRACT

BACKGROUND/OBJECTIVES: Nutrition knowledge has been reported to have a weak positive effect on healthy eating behavior. This study aimed to determine if there was a difference in nutrition knowledge depending on the choice of science subject in high school and whether that affected the actual eating habits of college students in Japan.
SUBJECTS/METHODS: The subjects were 514 college students, the majority first-year students, in 3 cities in Japan. A questionnaire survey was conducted on elective subjects in science in high school, diet (11 items), lifestyle (5 items), and nutrition knowledge (34 questions). The preliminary survey was conducted on 47 students in the fall of 2019, and the full-scale survey was conducted in May–June and October–November 2021 at the end of lectures for the first-year students.
RESULTS: The students in the high-score group (24–31 points, n = 180) had a higher intake of vegetables (odds ratio [OR], 1.78; 95% confidence interval [CI], 1.12–2.82; $P = 0.015$) and breakfast (OR, 1.64; 95% CI, 1.03–2.60; $P = 0.035$), and a reduced intake of fast food (OR, 0.27; 95% CI, 0.14–0.51; $P < 0.001$) than those in the low-score group (6–19 points, n = 150). Only the biology and chemistry students had significantly higher nutrition scores than the other groups (all: $P < 0.001$), but no significant difference was found between the other groups. Understanding nutrition learned in elementary and junior high school is appropriate, while molecular structure, recommended amount, and food poisoning were insufficient.
CONCLUSIONS: Knowledge of nutrition appears to have a positive effect on the actual eating habits of college students. Although biology and chemistry in high school may help students understand the foundations of good nutrition, specialized food education may be required to make informed dietary choices.

Keywords: Health knowledge, attitudes, practice; adolescent nutrition science

INTRODUCTION

Eating habits are influenced by many factors, including family, culture, availability, information, budget, and preferences. Although nutrition knowledge, including nutrition,

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Author Contributions

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nutrients, and food safety, are factors, there is a barrier to having it translate to actual behavior [1,2]. Nevertheless, it is recognized that nutrition knowledge has a weak but positive effect on healthy dietary habits [3-9]. Social cognitive theory [10] suggests that to change a specific behavior, a person needs to know what the required behavior is and how to perform it. Accurate knowledge about food and translating that into action are essential to a good diet. Eating habits are usually formed by adolescence. Hence, accurate knowledge and healthy habits will lead to favorable eating habits, which may prevent overweight or obesity over a lifetime [3].

The period from adolescence to adulthood, from ages 18–25 yrs, is also a period of independence from parents. During this time, adverse changes in diet and health, such as alcohol consumption, missing breakfast, and weight gain are often seen [11]. This is observed predominantly in students who leave their parents to attend university, who are adversely affected by the high cost of food and their own limited cooking experience [11].

In Japan, food and health were traditionally learned through home economics and health and physical education. These subjects are compulsory up to senior high school. Furthermore, since the Basic Law on Food Education was enacted in 2006, eating education (*shoku-iku* in Japanese) has become more common in schools and elsewhere. On the other hand, it is a science that deals with nutrients, such as proteins, carbohydrates, and fats, as well as metabolic processes in detail. In most high schools in Japan, the elective subjects of science differ greatly depending on the chosen career path, humanities/social studies courses, or science courses. This study examined the effects of high school elective science subject choice on nutrition knowledge and the effects on actual eating habits among college students in Japan.

SUBJECTS AND METHODS

Subjects

The subjects were 587 college students in 3 cities in northern Japan, with populations ranging from 300,000 to 800,000 (Morioka, Niigata, and Hachinohe). The number of students drawn from each city was as follows: 412 students in Morioka at a national university majoring in science and engineering, agriculture, education, and humanities and social sciences; 99 students in Niigata at a technical college for social welfare; 76 students in Hachinohe at a private university for health promotion science. The majority were first-year students (*i.e.*, freshmen). This research was approved by the Ethics Committee of Human Studies at Iwate University (No. 202101), and written informed consent was obtained from all subjects before participation.

As mentioned above, elective science subjects at senior high schools in Japan vary. There are generally 4 types as follows: 1) 2 to 3 subjects from fundamental physics, chemistry, biology, and earth science; 2) one subject from physics, chemistry, or biology in addition to 2 or 3 basic sciences; 3) physics/chemistry in addition to 2 or 3 basic sciences; 4) biology/chemistry in addition to 2 or 3 basic sciences. Students in humanities/social studies courses generally take only the basics. The aspirants for engineering and physics take physics and chemistry subjects. Other science course applicants, such as medicine, pharmacy, and agriculture, take physics/chemistry or biology/chemistry. Nursing, welfare, and private university applicants majoring in science often take one subject from physics/chemistry/biology according to their entrance examination. The subjects were divided into 4 classifications described above, and those that did not fit this category were excluded.

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Questionnaire

The questionnaire was anonymous. A preliminary survey was conducted on 47 students in the fall of 2019, and a full-scale survey was conducted in May–June and October–November 2021 at the end of lectures for the first-year students. Subjects were given 20 min to complete the questionnaire. The questionnaire included questions about age, sex, choice of science subject in high school, frequency of food intake (11 items), and lifestyle questions (5 items).

The frequency of food intake was evaluated on an 8-point scale, from eating very little to eating 3 times per day. The living situation survey evaluated the following on a 5-point scale: housing (living with their parents, boarding house, and dormitory/rental apartment), breakfast, TV watching, personal computer/smartphone use, and exercise frequency. The nutrition knowledge section, which consisted of 34 questions on nutrients, metabolism, and food safety, was developed based on previous studies [8,12-14] and science and home economics textbooks in high school. The subjects chose from 4 possible choices; one point was given for each correct answer. The number of correct answers was used as the score for nutrition knowledge. The first 47 students took the same lecture for first-year students by Mitsui T and were asked to fill in their student ID numbers, and tests were conducted at 2-wk intervals to investigate reproducibility [13,14]. The original text of the questionnaire was in Japanese, which was translated into English for this paper.

Statistical analysis

The data are expressed as mean ± standard deviation or mean (range). An independent *t*-test was used to compare the mean values between males and females. A χ^2 test was performed with and within each sex. The frequency of food intake and lifestyles were divided into 3 or 4 categories for statistical analysis, and the participants were classified by sex and housing.

For comparisons between groups by elective science subject, one-way analysis of variance was performed, and each group was compared using Sheff's test when a significant *F*-value was found.

The association between the nutrition knowledge and intake of rice, vegetables, milk, fish, snacks, soft drinks, fast food, and breakfast was calculated using multiple logistic regression after adjusting sex, housing, and exercise habits. The frequency of food intake was divided into 2 groups, *e.g.*, intake of vegetables ≥ twice a day or < twice a day. The nutrition knowledge scores were divided into 3 groups: low, medium, and high. The odds ratios (ORs) with the corresponding 95% confidence intervals (CIs) were calculated. The statistical significance was set to $P \leq 0.05$. All statistical processing was performed using EZR (https://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmed.html).

RESULTS

Subjects

Seventy-three (12.4%) students were excluded from the data analysis because their science subject choice was unclear: 37 for choosing less than 2 basic science subjects, 32 for choosing more than 3 physics/chemistry/biology/earth science, 3 for no response of sex or age, and one for international students. The final number of participants was 514 (224 males, 290 females). The mean age of the participants was 19.0 yrs (range: 18–25 yrs). The number of students according to their science subject choice was as follows: science basics, 239; basics and biology or chemistry, 43; physics/chemistry, 141; biology/chemistry, 91.

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Reproducibility of the questionnaire

The correlation coefficient according to the retest method was as follows: rice, 0.606; bread, 0.749; noodles, 0.741; vegetables, 0.543; meat, 0.505; fish, 0.829; milk/yogurt, 0.796; chocolate and snacks, 0.745; soft drinks, 0.858; fast food, 0.769; housing, 0.950; breakfast, 0.897; TV watching, 0.897; smartphone and PC use, 0.749; exercise, 0.897; and nutrition knowledge score, 0.818.

Frequency of food intake and lifestyle

The number of students in boarding houses was included in the group of students who lived with their parents because this group was relatively small at 26. **Table 1** lists the differences in food intake and lifestyles between sexes and their living situation. The female students consumed significantly more vegetables, milk, snacks (all: $P < 0.001$), and breakfast ($P < 0.05$) than the males. Male students had a significantly higher habit of consuming soft drinks, not watching TV, and exercising (all: $P < 0.001$) and a significantly higher intake of fast food ($P < 0.05$) than females.

There was a difference in eating habits according to living situation. Above all, a decreased fish intake was seen in both male and female students living apart from their parents ($P < 0.001$). Decreased vegetable intake was observed only in males ($P < 0.05$) but not in females living apart from their parents. The breakfast intake was higher in students living with parents than in students living apart from parents for both males ($P < 0.05$) and females ($P < 0.01$). Among females, snacks ($P < 0.01$) and fast food ($P < 0.05$) intake were higher in students living with parents than in those living apart. All the participants had smartphones and personal computers, and 67.0% of males and 66.4% of females used them for more than 3 h a day. In contrast, the number of students who did not watch TV, both male and female, was significantly higher in students living apart from their parents ($P < 0.001$).

Nutrition score

The average nutrition score was 21.9 ± 4.6 and 21.2 ± 4.6 for males and females, but this trend toward higher scores in males did not reach significance ($t = 1.80$, $P = 0.072$). The nutrition scores according to high school science subject choice were as follows: basics only, 20.7 ±

Table 1. Frequency of food intake and lifestyle habitats by sex and living situation

Variables	Males (n = 224)	Females (n = 290)	χ^2	Males			Females		
				With parents (n = 75)	Living independently (n = 149)	χ^2	With parents (n = 154)	Living independently (n = 136)	χ^2
Rice ≥ 2 times/d	190 (84.8)	229 (78.9)	4.31	65 (86.7)	125 (83.9)	4.78	127 (82.5)	102 (75.0)	4.78
Bread ≥ 1 time/d	28 (12.5)	56 (19.3)	4.45	8 (10.7)	20 (13.4)	1.88	24 (15.6)	32 (23.5)	4.73
Noodle ≥ 1 time/d	12 (5.4)	12 (4.1)	4.61	2 (2.7)	10 (6.7)	1.67	4 (2.6)	8 (5.9)	3.86
Vegetable ≥ 2 times/d	71 (31.7)	139 (47.9)***	16.62	31 (41.3)	40 (26.8)	9.86	75 (48.7)	64 (47.0)	1.95
Meat ≥ 1 time/d	144 (64.3)	167 (57.6)	2.51	49 (65.3)	95 (63.7)	0.11	95 (61.7)	72 (52.9)	3.10
Fish ≥ 2 times/wk	120 (53.4)	155 (53.4)	1.95	61 (81.3)	59 (40.0)	35.00	115 (74.7)***	40 (29.4)	59.50
Milk ≥ 1 time/d	53 (23.7)	95 (32.3)***	20.54	19 (25.3)	34 (22.8)	0.23	46 (29.9)	49 (36.0)	4.27
Snack ≥ 1 time/d	28 (12.5)	63 (21.7)***	21.69	9 (12.0)	19 (12.8)	0.04	44 (28.6)**	19 (14.0)	13.27
Soft drink ≥ 1 time/d	40 (17.9)***	34 (11.7)	31.87	15 (20.0)	25 (16.8)	0.39	22 (14.3)	12 (8.8)	2.98
Fast food ≥ 1 time/wk	49 (21.9)*	38 (13.1)	7.36	16 (21.3)	33 (22.1)	2.32	25 (16.2)*	13 (9.6)	6.27
Breakfast always	98 (43.8)	166 (57.2)*	6.10	45 (60.0)**	53 (35.6)	12.15	95 (61.7)*	71 (52.2)	6.10
TV nothing	104 (46.4)***	88 (30.3)	7.24	24 (32.0)	80 (53.7)**	9.56	37 (24.0)	51 (37.5)*	6.21
PC/smartphone ≥ 3 h/d	150 (67.0)	192 (66.4)	2.73	45 (60.0)	105 (70.4)	4.51	105 (68.2)	87 (64.4)	2.18
Exercise ≥ 4 times/wk	83 (37.0)***	47 (16.2)	44.63	29 (38.7)	54 (36.2)	1.14	21 (13.6)	26 (19.1)	3.57

Values are presented as number (%).
*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$ vs. each counterpart.

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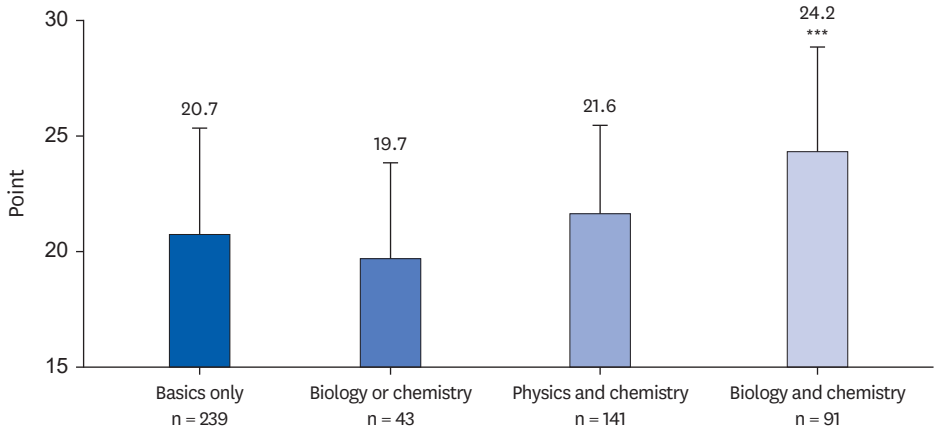

Fig. 1. Score of nutrition knowledge classified with the choice of science class in high school. The vertical bars showed the mean ± standard deviation. The biology and chemistry group score was significantly higher than other groups, and no significant differences were observed between other groups.
***$P < 0.001$.

4.6; one subject of biology or chemistry with some basics, 19.7 ± 4.1; physics/chemistry, 21.6 ± 3.8; and biology/chemistry, 24.2 ± 4.6 (**Fig. 1**). Only the biology/chemistry group score was significantly higher than the other groups (all: $P < 0.001$), and no significant difference was found between the other groups.

Table 2 lists 5 questions with high and low correct answer rates. More than 90% of students understood the nutrients and proper eating habits learned in elementary and junior high school. Nevertheless, the correct answer rates for molecular structure, recommended amount, and food poisoning questions were as low as approximately 20–30%.

OR of food intake frequency according to the nutrition knowledge level

The adjusted OR of the high-score group (24–31 points, n = 180) showed a higher intake of vegetables (OR, 1.78; 95% CI, 1.12–2.82; $P = 0.015$) and breakfast (OR, 1.64; 95% CI, 1.03–2.60;

Table 2. Five questions with a high correct answer rate (top) and 5 questions with a low correct answer rate (bottom)

No.	Questions	Correct answer (%)
Q17.	Which is the most starch food?	
	1. Bread 2. Meat 3. Butter 4. Cheese	1 (95.1)
Q22.	Which is the substrate that constitutes the human body mostly?	
	1. Protein 2. Water 3. Fat 4. Carbohydrate	2 (94.4)
Q28.	Which is the enzyme that decomposes starch?	
	1. Cellulase 2. Protease 3. Lipase 4. Amylase	4 (93.2)
Q32.	What is the work of DNA?	
	1. Maintaining body 2. Producing energy 3. Containing genetic material 4. Attacking pathogens	3 (93.8)
Q40.	Which are the most desirable diets?	
	1. Protein food 2. Fatty food 3. Carbohydrate free 4. Well balanced	4 (90.3)
Q26.	Which is a nutrient that contains nitrogen?	
	1. Protein 2. Carbohydrate 3. Fat 4. Mineral	1 (22.1)
Q34.	Which is the lightest molecular weight substance?	
	1. Maltose 2. Glucose 3. Starch 4. Lactose	2 (28.2)
Q38.	How much is the recommended daily intake of salt?	
	1. ≤ 3 g 2. ≤ 5 g 3. ≤ 8 g 4. ≤ 12 g	3 (24.7)
Q47.	Which are the food-poisoning bacteria that produce heat-tolerant toxin?	
	1. *Salmonella* 2. *Vibrio parahaemolyticus* 3. *Escherichia coli* O-157 4. *Staphylococcus aureus*	4 (19.4)
Q48.	What is a toxic substance found in moonshine?	
	1. Methanol 2. Ethanol 3. Acetone 4. Ethyl ester	1 (26.8)

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Table 3. OR of food intake frequency according to the nutrition knowledge level

Variables		OR	95% CI	*P*
Rice, ≥ twice /day				
Low	80.0%	1.00	Referent	-
Middle	80.5%	1.04	0.60–1.80	0.901
High	84.3%	1.43	0.80–2.56	0.234
Fruit and vegetable, ≥ twice/day				
Low	36.7%	1.00	Referent	-
Middle	41.6%	1.25	0.79–1.98	0.334
High	44.4%	1.78	1.12–2.82	0.015
Milk, ≥ once/day				
Low	28.0%	1.00	Referent	-
Middle	31.4%	1.24	0.77–2.00	0.381
High	26.8%	0.99	0.60–1.63	0.965
Fish, ≥ twice/week				
Low	55.3%	1.00	Referent	-
Middle	54.6%	1.04	0.49–2.18	0.922
High	50.8%	1.48	0.72–3.04	0.286
Snacks, ≥ once/day				
Low	19.3%	1.00	Referent	-
Middle	16.8%	0.96	0.54–1.71	0.895
High	17.3%	1.05	0.59–1.81	0.871
Soft drinks, ≥ once/day				
Low	18.0%	1.00	Referent	-
Middle	14.1%	0.70	0.39–1.28	0.254
High	11.7%	0.57	0.30–1.08	0.084
Fast food, ≥ once/week				
Low	26.0%	1.00	Referent	-
Middle	16.8%	0.51	0.30–0.89	0.016
High	9.5%	0.27	0.14–0.51	< 0.001
Breakfast, always				
Low	47.3%	1.00	Referent	-
Middle	51.9%	1.39	0.88–2.17	0.154
High	53.6%	1.64	1.03–2.60	0.035

Low score: 6–19 points, n = 150; middle score: 20–23 points, n = 184; high score: 24–31 points, n = 180. The OR was adjusted by sex, housing, and exercise habits.
OR, odds ratio; CI, confidence interval.

P = 0.035) than the low-score group (6–19 points, n = 150) (**Table 3**). The reduced odds of fast food were observed in the middle-score group (20–23 points, n = 184) (OR, 0.51; 95% CI, 0.30–1.08; *P* = 0.016) and high-score group (OR, 0.27; 95% CI, 0.14–0.51; *P* < 0.001) than the low-score group (**Table 3**).

DISCUSSION

Few studies have examined the relationship between nutrition knowledge and eating habits in the Japanese population. Nutrition knowledge was reported to have a positive effect on vegetable intake in children [7] and breakfast intake in adults [9]. To the best of the authors' knowledge, this is the first study on this topic among college students in Japan. As in previous studies, nutrition knowledge appears to have a positive effect on actual eating behavior: a higher intake of fruits, vegetables, and breakfast was related to greater nutrition knowledge. In particular, the marked decrease in fast food consumption may be due to those students having greater nutrition knowledge and making decisions based on that knowledge.

Nutrition knowledge appears to reflect educational attainment indirectly. Bonaccio *et al.* [5] reported that a higher educational background indicates the following: greater nutrition

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knowledge in adults in Italy; greater intake of Mediterranean cuisine rich in fruits, vegetables, fish, and olive oil; decreased body mass index. In Japan, it was observed that the influence of education and economic background on food and health was smaller than that in Europe and the United States [15]. On the other hand, the gap between rich and poor has been widening since the beginning of 2000 in Japan, and the low-income group in Japan tends to have a higher intake of grains and a lower intake of vegetables, fruits, and fish [16]. In the future, Japan might follow the United States and Europe in having high socioeconomic health inequality.

The most significant differences between the sexes were generally observed in eating and exercise habits. This study found that female students consumed more vegetables, milk, and breakfast, suggesting that they often cook their own meals and are more careful about their diet. The main reason is that women were more concerned about their body shape [8,11]. On the other hand, girls consume many snacks and chocolate [11], while males have a higher consumption of soft drinks [17] and perform more exercise [8]. The intake of snacks and fast food was higher in female students living with their parents than in those living apart from their parents in this study. There may be economic reasons for this. The Tokyo Federation of Private University Faculty and Staff Unions reported that the allowance of college students today had dropped sharply in the last 20–30 yrs, from 124,900 yen in 1994 to 82,400 yen in 2021 [18]. Students might need to reduce the money they spend on food, particularly fast food, snacks, and sweets.

In this study, the food with the most different consumption patterns between those living with and apart from parents was fish, which was more commonly consumed by those students living with their parents. This is probably because cooking fish is difficult and malodourous, particularly in a typically small student apartment. In this study, 43.8% of males and 57.2% of females always ate breakfast, and the habit of skipping breakfast was more common among students living apart from their parents, especially males. According to the National Nutrition and Health Survey 2017 [19], 69.4% of males and 76.4% of females in their 20s always ate breakfast. The relatively higher incidence of skipping breakfast in these results was probably because of the students' lack of time, poor cooking skills, and budget [11]. Many students are living alone for the first time, and they have to do everything, ranging from purchasing ingredients to cooking.

This study examined the effects of high school science subject choice on nutrition knowledge. Students who chose biology/chemistry, many of whom were students in the Faculty of Agriculture, had a significantly higher nutrition knowledge than the other groups. These students may also be more interested in food and health. On the other hand, the students who chose physics/chemistry, most of them majoring in mathematics, physics, or engineering, showed similar scores to those in the liberal arts and social sciences. The topic of nutrients and metabolism are included in the chapter on polymer substances in high school chemistry textbooks. This result is probably because engineering, mathematics, and physics students may have less interest in diet and nutrition. Teaching natural science, especially physics and chemistry, in relation to daily life can increase interest in students with low interest. Nutrition, health, and the environment are also useful for increasing literacy in the natural sciences because these topics interest certain scientists, engineers, and the general public.

The result of unclear responses to elective science subjects in 69 out of 587 (11.7%) students is probably because they enter college without having entrance examinations, such as

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English, mathematics, the national language, and science. Many colleges, including national universities, accept students without imposing entrance examinations for applicants. Therefore, they cannot recollect their high school science subjects.

In this study, the questions with correct answer rates of 90% or more were topics covered in elementary and junior high schools in Japan. On the other hand, there was a low understanding of the chemical structures of nutrients, recommended amounts, and types of food poisoning, at 20–30%. The energy metabolism, such as respiration and the chemical structure of nutrients, was not included in basic biology/chemistry classes in Japan. Without this knowledge, it would be difficult to understand the digestion and absorption of food and energy production. Furthermore, most students in Japan do not learn food safety and dietary intake standards at school. For the majority of the general public, even those without nutrition knowledge, it is possible to have a healthy diet to prevent lifestyle-related diseases, such as obesity, diabetes, and heart disease. Nevertheless, it is not enough to judge whether the nutrition information the media broadcasts can be trusted. A recent study reported that 66% of Norwegian college students and employees have difficulty understanding the nutrition information from the media [12].

This study had some limitations to this study. First, this study studied Japanese students. Hence, the findings may not apply to other countries with different cultures, diets, and education systems. In addition, the participants were college and vocational school students living in smaller regional cities in northern Japan. Therefore, the findings might differ. Second, the data could not be collected at once because of the coronavirus disease pandemic. The nutrition knowledge scores could be influenced by information from lectures and media after entering college. On the other hand, if the survey were conducted immediately after the students enter college, it would be impossible to investigate their lifestyle habits such as diet and exercise.

In conclusion, although the eating habits of college students are greatly affected by their living environment, greater nutrition knowledge appears to result in the higher consumption of vegetables, fruit, breakfast, and a lower consumption of fast food. The nutrition knowledge scores of those who took biology and chemistry in high school were relatively higher than those who did not choose these subjects. Most students appeared to have basic nutrition knowledge, but they had an insufficient understanding of the chemical structure of nutrients, types of food poisoning, and the recommended daily amounts of food. Although biology and chemistry classes in high school help give students some nutrition knowledge, specialized food education may be required to enable them to make good dietary lifestyle choices.

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