

# Stages of Behavioral Change for Fruit and Vegetable Intake in Adolescents: A School-Based Cross-Sectional Study in Japan

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## Abstract

**Objective:** The purpose of this study was to understand why adolescents choose to eat fewer fruits and vegetables by examining the stages of behavioral change and perceived barriers to fruits and vegetable intake in a school-based study in Japan.

**Methods:** A cross-sectional survey was performed at junior and senior high schools from 2018 to 2020, and 933 students aged 12–18 agreed to participate. A questionnaire obtained information on demographic characteristics, daily fruit and vegetable intake, and to assess the stage of change regarding eating more fruits and vegetables and barriers faced by the participants.

**Results:** The daily average amount of fruit and vegetable intake was 89.3 g and 178 g, respectively. In response to whether they were “Eating 350 g or more vegetables and 200 g or more fruits a day most day,” 52.6% answered “not thinking about doing it” (precontemplation stage); the ratio was particularly high among males (61.1%). Moreover, as the stage of change increased from precontemplation to action/maintenance, the daily intake of fruits and vegetables increased and the perceived barriers decreased. We also found that environment when dining out, personal habits, and family and self-preference were perceived as the most important factors related to barriers to eating more fruits and vegetables.

**Conclusion:** This study suggests that stage-tailored interventions need to target the above-mentioned barriers, particularly for students in the precontemplation and contemplation stages, and to enhance knowledge on the health benefits of fruits and vegetables, as well as consider a gender-specific approach.

**Keywords:** stages of change, fruit and vegetable intake, barriers, adolescents

## 1. Introduction

It is known that nutrient needs increase during adolescence, and inadequate nutrition during this period can result in physical growth delays and further influence the health of adulthood and future generations negatively (Whitney, & Rolfes, 2002; Das, Lassi, Hoodbhoy, & Salam, 2018; Viikari, Raitakari, & Simell, 2002). A high intake of fruits and vegetables in adolescents was reported to be associated with better perceived general health, oral health, happiness, sleep satisfaction, and academic achievement (Park, Rim, & Lee, 2018; Burrows, Goldman, Pursey, & Lim, 2017). Epidemiological studies have shown the contribution of fruit and vegetable intake in preventing many chronic diseases such as coronary heart disease, hypertension, stroke, and cancer (Ness, & Powles, 1997; Joshipura et al., 1999; Block, Patterson, & Subar, 1992; Dauchet, Amouyel, & Dallongeville, 2009; Boeing et al., 2012) by the mechanisms of their antioxidant, anti-inflammatory, anti-aggregatory properties, and hypocholesterolemic action (Lampe, 1999). However, the low intake of fruits and vegetables among adolescents has been reported in 33 European and North American countries/regions (Vereecken et al., 2015) and some Southeast Asian countries (India, Indonesia, Myanmar, Sri Lanka, and Thailand) (Peltzer, & Pengpid, 2012; Rathi, Riddle, & Worsley, 2017). In Japan, the average intake of fruits and vegetables was 62.1 g and 256.7 g, respectively, per day among people aged 15–19 based on the 2018 National Health and Nutrition Survey (NHNS) (National Institute of Health and Nutrition [NIHN], 2018). These amounts are far below the recommended daily requirements of vegetables (350 g or more) and fruits (200 g or more) (Sakurai, 2003; Ministry of Agriculture, Forestry and Fisheries [MAFF], 2022a). Our previous study of Japanese junior and senior high school students also showed that many students did

not know the recommendation for the amount of fruit and vegetable intake, but still considered their intake to be sufficient (Sato, Miyanaga, & Wang, 2020a). A study in Austria reported that in a survey of adults, 50% of those who reported consuming less than 1 serving (80 g) of vegetables per day said that they were eating enough (Schatzer, Rust, & Elmadfa, 2009). Understanding the real reasons why adolescents in Japan do not consume more fruits and vegetables will contribute to the development of effective nutritional intervention programs.

The transtheoretical model (TTM) in behavioral sciences has been applied to predict behavioral change and health education intervention for those who have inadequate dietary intake based on the stages of readiness for change (Prochaska, & Velicer, 1997; Havas et al., 1998; Nakabayashi, Melo, & Toral, 2020; Wang et al., 2016), and some results suggest that TTM-based interventions are efficient in improving dietary intake among adolescents (Nakabayashi et al., 2020). However, in Japan, there is a lack of data addressing the association of the stage of behavioral change with daily fruit and vegetable intake and psychological factors among adolescents. We previously reported positive attitudes, self-efficacy and perceived barrier were associated with fruit and vegetable intake in adolescents, but it is unknown how the stage of behavioral change associates with fruit and vegetable intake and psychological factors (Sato et al., 2020a). The present study aimed to understand why adolescents choose to consume fewer fruits and vegetables by examining the stage of behavioral change and perceived barriers to fruit and vegetable intake in a school-based study in Japan.

## 2. Method

### 2.1 Participants and Procedure

Research participants were recruited between June 2018 and February 2020 from two convenience-sampled junior and senior high schools, where there were research collaborators, in the cities of Okayama and Wakayama, Japan. Self-reported data were collected through anonymous questionnaires distributed in the classroom. A total of 933 students (male: 332, female: 601) aged 12–18 years agreed to participate in the study (1020 questionnaires were distributed, 87 did not accept to participate in the study, 933 were collected; response rate: 91.5%). This study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki, and all procedures involving study participants were approved by the Ethics Committee of Okayama University of Science (No. 30-3). Verbal informed consent was obtained from all participants prior to the survey.

### 2.2 Measures

The questionnaire survey obtained information on demographic characteristics, daily fruit and vegetable intake (instructions and examples were presented in the questionnaire. For examples, “One small bowl of vegetables is approx. 70g.”, “One medium apple or pear weighs approx. 200g” and “Two medium oranges or kiwis weigh approx. 200g”. Participants were asked to recall their daily average fruit and vegetable intakes by portion size and then to convert portion size into grams of daily fruit and vegetable intakes (g/day) based on the calculating examples given in the questionnaire); the awareness of recommended daily fruit and vegetable intake was also collected by asking questions regarding “Do you know the recommended amount of vegetable intake (350g/day)?” and “the recommended amount of fruit intake (200g/day)” (Sato et al., 2020a; Havas et al., 1998; Wang et al., 2016).

The questions to assess the stage of change regarding eating more fruits and vegetables were adapted from Havas et al. (1998). they measured for 5 eating behaviors by asking questions regarding “Eating 350 g or more vegetables and 200 g or more fruits a day most day,” “Eating a green salad or another vegetable for lunch most days,” “Eating 2 or more servings of vegetable for dinner most days,” “Having 100% juice or fruit in the morning most days,” and “Eating more fruits and vegetables” in a 4-choice response format. Based on the TTM of behavioral change (Prochaska & DiClemente, 1983), the responses to the questions were converted into the following four stages: precontemplation stage = 1 (not thinking about doing it), contemplation stage = 2 (thinking about starting to do it in the next 6 months), preparation stage = 3 (definitely planning to start doing it in the next months), and action/maintenance stage = 4 (already doing it). The mean stage value was calculated as the average of the individual stage category scores.

The measurement of perceived barriers to fruit and vegetable intake was described else-where (Sato et al., 2020a); in brief, it was measured by summing responses to 18 questions regarding taste, cost, availability, season shortage, personal habits, family preference, personal judgment, and comprehension of fruits and vegetables. Each item was scored on a 5-point Likert scale ranging from “agree a lot” to “disagree a lot.”

### 2.3 Statistical Analysis

All statistical analyses were conducted using the IBM SPSS Statistics version 26.0 software for Windows (IBM SPSS Inc., Chicago, IL, USA). Two-group comparisons were performed using Pearson’s Chi-Square test for the

categorical variables and subsequently by post-hoc adjusted residual analysis. A trend analysis (based on linear-contrast one-way analysis of variance) was also performed to examine the relationship of fruit and vegetable intake with the stages of change. Variables with skewed distributions were log-transformed. The results were considered significant at the 5% level.

We also conducted an exploratory factor analysis (unweighted least-squares extraction method with varimax rotation) to identify the underlying factor structure of barriers to eating more fruits and vegetables. To determine the reliability of the factors, the internal consistency was calculated for each construct of the resulting factors using Cronbach's alpha coefficient.

### 3. Results

#### 3.1 Characteristics of Participants

The participants' characteristics are presented in Table 1. There were 35.6% male and 64.4% female participants, of which 8.4% were junior high school students and 91.6% were high school students. The mean age of the participants was 15.7 years, with a standard deviation of 1.0. The daily average amount of fruit and vegetable intake was 89.3 g and 178 g, respectively. Daily fruit intake was higher among female participants compared to male participants, but we did not find any gender differences in vegetable intake.

Table 1. Characteristics of Participants

|  | Total                 | Male                  | Female                  |
|--|-----------------------|-----------------------|-------------------------|
| Age (mean $\pm$ SD)  | 15.7 $\pm$ 1.0 (933)  | 15.8 $\pm$ 0.7 (332)  | 15.7 $\pm$ 1.2 (601)    |
| Class  |                       |                       |                         |
| Junior high school students                                | 78 (8.4 %)            | 0 (0 %)               | 78 (13.0 %)             |
| High school students                                       | 855 (91.6%)           | 332 (100 %)           | 523 (87.0%)             |
| Self-reported fruit intake (g/day)<br>(mean $\pm$ SEM)     | 89.3 $\pm$ 5.1 (376)  | 79.4 $\pm$ 10.2 (103) | 93.1 $\pm$ 5.8 (273) ** |
| Self-reported vegetable intake (g/day)<br>(mean $\pm$ SEM) | 178.0 $\pm$ 7.1 (336) | 178.7 $\pm$ 16.0 (90) | 177.7 $\pm$ 7.7 (246)   |

Notes. Values in parentheses denote the number of respondents; \*\*  $p < 0.01$  (Male vs. female by Student t test).

Data were log-transformed before the analysis.

#### 3.2 Distribution in the Stage of Change for Fruit and Vegetable Intake and Mean Stage of Change Value

Table 2 summarizes the distribution in the stage of change for eating more fruits and vegetables. Since there was no significant difference between the participants in the two study areas, the data from the two areas were analyzed together. In response to whether they were "Eating 350 g or more vegetables and 200 g or more fruits a day most day," more than half of the participants (52.6%) answered "not thinking about doing it" (precontemplation stage); the ratio was particularly higher in males than females. ( $p < 0.01$ , adjusted residual  $> 1.96$ ), and only 14% of male participants answered "already doing it" (action/maintenance stage); whereas the ratio of females in contemplation stage was approximately 1.5 times higher than that of males (adjusted residual  $> 1.96$ ). When questioned whether they were "Eating a green salad or another vegetable for lunch most days," nearly half of the male participants (43.0%) and female participants (47.3%) responded "already doing it" (action/maintenance stage). Approximately one-third of the participants were in the precontemplation stage, and male participants were more likely to be in the precontemplation stage than female participants ( $p < 0.01$ , adjusted residual  $> 1.96$ ).

In response to whether they were "Eating 2 or more servings of vegetable for dinner most days," nearly half of the male participants were in the precontemplation stage (Table 2, adjusted residual  $> 1.96$ ), and the ratios of male participants were smaller in the action/maintenance stages compared to those of female participants ( $p < 0.01$ , adjusted residual  $> 1.96$ ).

In response to whether they were "Having 100% juice or fruit in the morning most days," about 41.6% of the participants were in the precontemplation and 22.0% in the contemplation stages. More than half of the male participants were in the precontemplation stage (51.7%), and their ratios were smaller in the contemplation and preparation stages compared to those of female participants ( $p < 0.01$ , adjusted residual  $> 1.96$ ).

In response to whether they were “Eating more fruits and vegetables,” there were 1.8 times more male participants in the precontemplation stage compared to the female participants (adjusted residual > 1.96). Only one-fourth of the participants (male: 24.5%, female: 26.5%) were in the action/maintenance stage (Table 2). As shown in Table 2, the mean stage of change value for fruit and vegetable intake in each question response was lower in males than in females.

Table 2. Distribution of participants over all stages of change for eating more fruits and vegetables

|   | Total <sup>b</sup> | Male                    | Female                  |
|---|--------------------|-------------------------|-------------------------|
| Eating 350g or more vegetable and 200g or more fruit a day most day <sup>#,†,††</sup> |                    |                         |                         |
| Precontemplation  | 488 (52.6)         | 201 (61.1) <sup>a</sup> | 287 (47.9)              |
| Contemplation   | 249 (26.8)         | 67 (20.4)               | 182 (30.4) <sup>a</sup> |
| Preparation   | 44 (4.7)           | 15 (4.6)                | 29 (4.8)                |
| Action/Maintenance  | 147 (15.8)         | 46 (14.0)               | 101 (16.9)              |
| Median stage (IQR)  |                    | 1 (1-2)                 | 2 (1-2)                 |
| Eating a green salad or another vegetable for lunch most days <sup>†,††</sup>         |                    |                         |                         |
| Precontemplation  | 291 (31.3)         | 124 (37.6) <sup>a</sup> | 167 (27.8)              |
| Contemplation   | 161 (17.3)         | 42 (12.7)               | 119 (19.8) <sup>a</sup> |
| Preparation   | 52 (5.6)           | 22 (6.7)                | 30 (5.0)                |
| Action/Maintenance  | 426 (45.8)         | 142 (43.0)              | 284 (47.3)              |
| Median stage (IQR)  |                    | 2 (1-4)                 | 3 (1-4)                 |
| Eating 2 or more servings of vegetable for dinner most days <sup>†,††</sup>           |                    |                         |                         |
| Precontemplation  | 316 (34.1)         | 139 (42.0) <sup>a</sup> | 177 (29.7)              |
| Contemplation   | 209 (22.6)         | 69 (20.8)               | 140 (23.5)              |
| Preparation   | 54 (5.8)           | 20 (6.0)                | 34 (5.7)                |
| Action/Maintenance  | 347 (37.5)         | 103 (31.1)              | 244 (41.0) <sup>a</sup> |
| Median stage (IQR)  |                    | 2 (1-4)                 | 2 (1-4)                 |
| Having 100% juice or fruit in the morning most days <sup>†,††</sup>                   |                    |                         |                         |
| Precontemplation  | 387 (41.6)         | 171 (51.7) <sup>a</sup> | 216 (36.0)              |
| Contemplation   | 205 (22.0)         | 61 (18.4)               | 144 (24.0) <sup>a</sup> |
| Preparation   | 68 (7.3)           | 12 (3.6)                | 56 (9.3) <sup>a</sup>   |
| Action/Maintenance  | 271 (29.1)         | 87 (26.3)               | 184 (30.7)              |
| Median stage (IQR)  |                    | 1 (1-4)                 | 2 (1-4)                 |
| Eating more fruits and vegetables <sup>†,††</sup>                                     |                    |                         |                         |
| Precontemplation  | 266 (28.6)         | 134 (40.5) <sup>a</sup> | 132 (22.0)              |
| Contemplation   | 298 (32.0)         | 75 (22.7)               | 223 (37.2) <sup>a</sup> |
| Preparation   | 126 (13.5)         | 41 (12.4)               | 85 (14.2)               |
| Action/Maintenance  | 240 (25.8)         | 81 (24.5)               | 159 (26.5)              |
| Median stage (IQR)  |                    | 2 (1-3)                 | 2 (2-4)                 |

Notes. Values in the parenthesis denote percentage.

# Recommendation level of daily vegetable and fruit intake in Japan.

† p < 0.01 (Males vs. females by Chi-square test), †† p < 0.01 (Difference among stage by Chi-square test)

<sup>a</sup> adjusted residual > 1.96

<sup>b</sup> Some participants who did not answer the above questions were excluded from the analysis; therefore the total numbers of the groups for each question were different.

### 3.3 Fruit and Vegetable Intake and Perceived Barriers across the Stage of Change

In response to “Eating 350 g or more vegetable and 200 g or more fruit a day most day,” we found that the participants in precontemplation and contemplation stages consumed fewer fruits and vegetables; their daily intake of both fruits and vegetables tended to significantly increase as the stage of change increased from precontemplation to action/maintenance ( $p$  trend < 0.01) (Table 3). In contrast, the scores of perceived barriers were higher among participants in the precontemplation and contemplation stages, and the scores of perceived barriers tended to decrease as the stage of change increased ( $p$  trend < 0.01). In particular, the score of perceived barriers to eating more fruits and vegetables was the lowest among participants in the action/maintenance stage.

Table 3. Daily fruit/vegetable intakes and perceived barriers across stage of change<sup>a</sup>

|   | Mean ± SEM (n <sup>c</sup> ) |
|---|------------------------------|
| <b>Vegetable intake (g/day)<sup>b</sup></b>                             |                              |
| Precontemplation  | 142.6 ± 9.0 (157)            |
| Contemplation   | 155.4 ± 9.9 (95)             |
| Preparation   | 198.9 ± 49.2 (9)             |
| Action/Maintenance  | 281.0 ± 17.3 (73)            |
| <b>Fruit intake (g/day)<sup>b</sup></b>                                 |                              |
| Precontemplation  | 65.8 ± 7.1 (183)             |
| Contemplation   | 83.1 ± 7.2 (106)             |
| Preparation   | 113.9 ± 25.4 (9)             |
| Action/Maintenance  | 148.8 ± 12.4 (75)            |
| <b>Scores of perceived barriers across stages of change<sup>b</sup></b> |                              |
| Precontemplation  | 44.1 ± 0.5 (461)             |
| Contemplation   | 44.7 ± 0.8 (235)             |
| Preparation   | 41.0 ± 2.1 (41)              |
| Action/Maintenance  | 36.8 ± 1.1 (140)             |

Notes. <sup>a</sup> Four stages of change were converted from the answers of the question “Eating 350 g or more vegetables and 200 g or more fruits a day most day”.

<sup>b</sup>  $P$ trend < 0.01.

<sup>c</sup> Some participants who did not answer the above questions were excluded from the analysis; therefore the total numbers of the groups for each question were different.

### 3.4 Factors of Perceived Barriers to Eating More Fruits and Vegetables

In Table 4, an exploratory factor analysis showed that a 5-barrier factors structure with eigenvalues > 1 explained 49.91% of the total variance and was the best-fitting model. The structure contained (1) cost/distribution factors (6 items, Cronbach’s  $\alpha$  = 0.87), (2) family and self-preference (6 items, Cronbach’s  $\alpha$  = 0.77), (3) environment when dining out (2 items, Cronbach’s  $\alpha$  = 0.74), (4) personal perceptions (2 items, Cronbach’s  $\alpha$  = 0.63), and (5) personal habits (2 items, Cronbach’s  $\alpha$  = 0.58). All factor loadings exceeded 0.41, among which “environment when dining out,” “personal habits,” and “family and self-preference” were perceived as the most important factors related to barriers to eating more fruits and vegetables.

Table 4. Factor analysis on perceived barriers to eating more fruits and vegetables

| Perceived barriers   | Factor loading |
|--|----------------|
| <b>Cost/distribution factors (Cronbach's <math>\alpha = 0.87</math>)</b>                         |                |
| Eating 200g or more fruits a day is difficult because they cost too much                         | 0.74           |
| Eating 5 or more servings of vegetables a day is difficult because they cost too much            | 0.73           |
| Eating 5 or more servings of vegetables a day is difficult because we run out of them at home    | 0.73           |
| Eating 200g or more fruits a day is difficult because we run out of them at home                 | 0.72           |
| Eating 5 or more servings of vegetables a day is difficult because there are few kinds in winter | 0.66           |
| Eating 200g or more fruits a day is difficult because there are few kinds in winter              | 0.61           |
| <b>Family and self-preference (Cronbach's <math>\alpha = 0.77</math>)</b>                        |                |
| My family doesn't like fruits  | 0.77           |
| I don't like the taste of many fruits  | 0.65           |
| My family doesn't like vegetables  | 0.63           |
| It is troublesome to eat fruits  | 0.57           |
| I don't like the taste of many vegetables  | 0.50           |
| It's troublesome to cook. I don't know how to cook.  | 0.45           |
| <b>Environment when dining out (Cronbach's <math>\alpha = 0.74</math>)</b>                       |                |
| Vegetables are not always availability when I eat away from home                                 | 0.80           |
| Fruits are not always availability when I eat away from home                                     | 0.57           |
| <b>Personal perceptions (Cronbach's <math>\alpha = 0.63</math>)</b>                              |                |
| I think I'm eating enough vegetables now   | 0.68           |
| I think I'm eating enough fruits now   | 0.63           |
| <b>Personal habits (Cronbach's <math>\alpha = 0.58</math>)</b>                                   |                |
| Having 100% juice or fruit in the morning is difficult because I don't have such a habit         | 0.78           |
| Having 100% juice or fruit in the morning is difficult because they are not filling              | 0.41           |

Notes. Factor analysis was performed by unweighted least squares extraction method with varimax rotation.

#### 4. Discussion

According to the results of NHNS in Japan, in recent years, fruit and vegetable intakes for each age group in both males and females have been below the recommended amount, and less than 40% target attainment rate for fruit and vegetable intake in each age group (Sato, Miyanaga, & Wang, 2020b). Analysis of 1999-2018 NHNS data showed that the people in the group under-20 years of age had the lowest daily vegetable intake (211.5 g/day) among all age groups, and had a relatively low daily fruit intake (98.6 g/day) in comparison with the group over 50 years of age (Sato et al., 2020b). The current results demonstrated daily average amount of fruit and vegetable intake was 89.3 g and 178 g, respectively, in participants aged 12-18 years, which are far below the daily target level of fruits and vegetables (Sakurai, 2003; Ministry of Agriculture, Forestry and Fisheries [MAFF], 2022a). Such low intakes of fruits and vegetables among adolescents in Japan were consistent with those reported in European and some North American countries/regions (Vereecken et al., 2015) and Southeast Asian countries (Peltzer & Pengpid, 2012; Rathi, Riddle, & Worsley, 2017). These findings suggest that promoting fruit and vegetable consumption among adolescents should be set as one of the public health priorities for disease prevention in their adulthood.

The TTM, used to predict and promote behavioral change, is a useful framework for research on understanding multiple behaviors in the general population (Prochaska & Velicer, 1997; Havas et al., 1998; Nakabayashi et al., 2020; Prochaska & DiClemente, 1983; Marshall & Biddle, 2001). To our knowledge, the present study is the first attempt to examine the stages of behavioral change for increasing fruit and vegetable intake among Japanese adolescents. The stage distributions for fruit and vegetable intake demonstrated that the majority of the adolescent

participants did not consider behavioral changes to try to eat more fruits and vegetables as recommended. One of the reasons that many participants answered “not thinking about eating more fruits and vegetables as recommended” might be because they had less knowledge of fruit and vegetable recommendations. At elementary and junior high schools in Japan, the students learn food knowledge and cooking methods in Home Economics, Physical Education, and school lunch, etc. However, we previously reported that more than 97% of the participants did not know the recommendations to eat at least 350 g vegetables and 200 g fruits per day (Sato et al., 2020a); the unawareness of fruit and vegetable recommendations was high among adolescents (Sato et al., 2020a) compared to adults (75.2% for vegetables and 86.8 % for fruits) in Japan (Wang et al., 2016), suggesting that there is a necessity of improving nutrition education in elementary and junior high schools, and extra efforts are needed to popularize knowledge of target levels and health benefits to increase the adolescents’ fruit and vegetable intake.

Participants who were in stages of precontemplation and contemplation showed the highest scores for perceived barriers to eating more fruits and vegetables. In our previous study, we found that the highest score of perceived barriers to vegetable intake in both male and female participants was “Eating 350 g or more vegetable and 200 g or more fruit a day most day is difficult because I think I’m eating enough now” (Sato et al., 2020a), whereas in reality, they are eating much less than the target levels. This indicates that the participants incorrectly perceived their fruit and vegetable intake to be high and, therefore, did not perceive any need to change their dietary behavior. Our study also showed a higher factor loading for barriers to fruit intake was “Having 100% juice or fruit in the morning is difficult because I don’t have such a habit.” The current finding by factor analyses demonstrated that factors like “environment when dining out,” “personal habits,” and “family and self-preference” made the adolescent participants less likely to consume more fruits and vegetables. The present results also showed that as the stage of change increased from precontemplation to action/maintenance, daily intake of fruits and vegetables tended to increase, while the perceived barriers decreased. Also, the previous study reported a significant negative correlation between perceived barriers and daily fruit and vegetable intake (Sato et al., 2020a). Therefore, approaches to reducing these barrier factors are important for stage transitions from precontemplation and contemplation to preparation and progress further to action/maintenance.

In response to whether they were “Eating a green salad or another vegetable for lunch most days,” 45.8% of the total participants were in the action/maintenance stage, compared with their response to whether they were “Eating 2 or more servings of vegetable for dinner most days,” only 37.5% in the action/maintenance stage (adjusted residual = 12.2). These results suggested that the participants might eat more vegetables at lunch instead of dinner. A plausible reason might be that these students usually eat a homemade boxed meal called BENTO at lunch. Making visually attractive BENTO is now widespread not only in Japan but also in Europe and the United States (USA). A dietary education program on how to make the BENTO look good has also been developed (Akaori, 2018). The BENTO can be made colorful with green vegetables; thus, the students who eat BENTO at lunch may consume more vegetables.

Based on the results of the factor analysis (Table 4), the “family and self-preference” is also one of the critical barrier factors to low level of fruit and vegetable intake in the present study. Gross et al. reported that family influence was the key to fruit and vegetable intake among children in the USA (Gross, Pollock, & Braun, 2010). Several studies also showed that unhealthy school/home food environments and the lack of nutrition knowledge and healthy meal preparation among parents and school canteen staff were some of the main barriers to promoting adolescents’ healthy eating (Rathi, Riddell, & Worsley, 2018a; Rathi, Riddell, & Worsley, 2018b; Rathi, Riddell, & Worsley, 2020), suggesting that intervention strategies for adolescents should focus not only on individuals but also on family and foodservice providers.

Daily fruit intake was significantly higher among female participants compared to their male counterparts. In our previous finding, the male participants reported higher scores of perceived barriers to fruit intake, particularly choosing the responses “I don’t like them”, “My family don’t like them”, and “I’m eating enough now,” than female participants (Sato et al., 2020a). From the stages of change perspective, the mean stage value for fruit and vegetable consumption among male participants was significantly low in response to whether they were “Eating 350 g or more vegetable and 200 g or more fruit a day most day,” “Eating 2 or more servings of vegetable for dinner most days,” “Having 100% juice or fruit in the morning most days,” and “Eating more fruits and vegetables.” A higher ratio of male participants answered: “not thinking about performing the above action” (precontemplation stage). The findings imply that the status of a low fruit and vegetable intake among adolescents can be improved by developing stage-tailored and gender-specific intervention programs, particularly for those in the precontemplation and contemplation stages. Stables et al. (2002) reported that the approach to enhance public awareness of guidelines and health benefits of fruits and vegetables showed a significant improvement in the population’s fruit and vegetable intake. Recently, the Ministry of Agriculture, Forestry and Fisheries of Japan

(MAFF) has opened a YouTube channel called “BUZZ MAFF” (MAFF, 2022b). The “BUZZ MAFF” is a project in which the staff of the MAFF themselves become YouTubers and convey the goodness of Japan’s agriculture, forestry and fisheries products. The number of subscribers has exceeded 100,000, and the channel was featured in the media. The “BUZZ MAFF” also contains an educational video that introduces the recommended intake of fruits and vegetables and their health benefits. In Japan, the ratio of the population aged 13–19 years with access to the Internet was 98.4% in 2019 (Ministry of Internal Affairs and Communications of Japan [MIC], 2019); therefore, nutrition education through the Internet and social networking services is probably one of the most effective ways to promote eating more fruits and vegetables among adolescents.

Although our study characterized the stages of behavioral changes and perceived barriers to fruit and vegetable intake in a school-based study in Japan, some limitations of the study should be considered. First, the present study was carried out only in two cities, and the results do not necessarily represent all adolescents in Japan. In addition, less than two-thirds of the participants were female, most of them were high school students, and all the males were high school students. Future studies with sample groups from other areas of Japan and from different age groups of adolescents are needed. Second, potential bias in self-reported fruit and vegetable intake may be introduced. The average daily vegetable intake reported by our participants (aged 12–18) was 178.0g/day, which is lower than the latest results of the NHNS in Japan for those aged 7–14 (234.1 g/day in 2018 and 232.8 g/day in 2019) and 15–19 (256.7 g/day in 2018 and 246.9 g/day in 2019), respectively (NIHN, 2018; NIHN, 2019). Possible reasons for the differences may be partially due to the differences of the food record method, the regions the participants from, and the participants’ age. In our previous report, about 60% of the students reported that they were not aware of their intake of fruits and vegetables (Sato et al., 2020a), this may result in underestimation of fruit and vegetable intake of the participants, the results should be interpreted with caution. Third, the socio-economic status might be a potential confounder, for example, some participants’ families have lower household income, and education levels may make them consume fewer fruits and vegetables; however, unfortunately, data on household incomes and educational levels were not available. Fourth, causal relationships could not be determined because the study was cross-sectional. Fifth, the Cronbach’s alpha values of personal habits (Cronbach’s  $\alpha = 0.58$ ) and personal perceptions (Cronbach’s  $\alpha = 0.63$ ) were relatively low, however, these factors might imply that participants lacked knowledge of the disease-preventing effect of vegetables and fruits intake. These findings may be useful information in designing effective intervention programs. Sixth, we attributed higher vegetable intake to lunch BENTO, unfortunately information about the participants’ use of BENTO was unavailable.

Many scientists have indicated that dietary habits established in childhood/adolescence might be carried over into adulthood and have a further, independent influence on health (Viikari et al., 2002; Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2004; Berenson, Srinivasan, & Nicklas, 1998; Lucas, 1998; Barker, 2000). Several studies have shown that children with picky eating have a lower intake of fruits and vegetables than the non-picky eating group and are associated with lower nutrient intakes (Galloway, Lee, & Birch, 2003; Cooke, Wardle, & Gibson, 2003; Jacobi, Agras, Bryson, & Hammer, 2003, Tharner et al., 2014; Viljakainen, Figueiredo, Rounge, & Weiderpass, 2019; Pesch, Bauer, & Christoph, 2019; Gan, Tithecott, Neikson, Seabrook, & Dworatzek, 2021). Therefore, establishing good dietary habits of eating a variety of fruits and vegetables as early as possible through family- and school-based interventions might make them change their dietary behaviors and further contribute to reducing the risk of chronic diseases in their adulthood.

In conclusion, the current findings suggest that effective stage-tailored interventions require targeting availability, personal habits, and family preference; they need to enhance knowledge on the health benefits of fruits and vegetables, in which gender-specific approaches should also be considered.

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### Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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