ORIGINAL

Association between subjective emotions and food choice behavior in the general Japanese population : An internet panel survey

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Abstract : Purpose : This study aimed to clarify the association between subjective emotions and food choice behavior in Japanese adults aged 18 years or older. Methods : Five hundred Japanese adults completed an online questionnaire. We collected data on the participants' characteristics, lifestyle, and changes in food group selection under normal conditions and six emotional states (anger, disgust, fear, happiness, sadness, and surprise). We calculated the dietary balance score (DBS) based on the frequency of intake for 10 food groups. Estimated mean DBS and intake frequency of its components during each emotional state were assessed using generalized estimating equations. Results : More than half of participants (59.6%) reported that their food selection usually changed according to their emotional state. The DBS score was lower in all six emotional states than in the normal state in both sexes. Sadness decreased intake frequency of the DBS components in both sexes. Additionally, the frequency of confectionery and beverage intake during happiness increased compared to the normal state in both sexes. Conversely, the frequency of confectionery intake during sadness decreased compared to the normal state in both sexes. Conclusion : Emotions, especially sadness and happiness, may affect the frequency of food group intake and dietary balance in Japanese adults. J. Med. Invest. 73 : 241-250, February, 2026

Keywords **:** *emotion, food choice, Japanese people, nutritional epidemiology*

INTRODUCTION

Food choice results from a complex interplay between internal and external factors. Internal factors include emotions, mood, food preferences, nutritional knowledge, hunger, body image, and personal beliefs about diet and health. In contrast, external factors include cultural and social influences, economic conditions, seasonality, and accessibility (1, 2). Among internal factors, emotions, especially negative emotions, have been shown to substantially affect dietary intake (3).

Previous studies have shown that negative emotions and stress can lead to unhealthy eating behaviors such as increased consumption of sweet snacks and fast food (4). Evidence suggests that atypical depression is associated with increased energy intake, whereas typical responses to stress and negative emotions often involve reduced food consumption (5). Both remitted and current depressive disorders have been linked to higher emotional and external eating, respectively (6). Current depression severity has been associated with lower diet quality and higher intake of sweet foods and snack/fast food items (7). Importantly, even among healthy adults without a clinical diagnosis of depression, observational studies have reported associations between negative mood states (e.g., stress, depression, and anxiety) and dietary behavior (8, 9). For example, in a sample of shift workers, negative mood mediated the relationship between shift type and energy intake and was associated with higher fat intake (8). Additionally, a cross-sectional study of middle-aged women found that depressive symptoms were positively associated with sweet food consumption and negatively associated with non-sweet food consumption (9). However, most of these studies were conducted in Western populations, where food cultures and beliefs differ. However, evidence of these associations in Asian populations is limited.

To address this gap, we examined the associations between discrete emotional states and dietary quality, intake frequency of food group, and eating behaviors in Japanese adults using an online survey. Investigating these relationships in a non-Western context will contribute to a better understanding of how transient emotions affect dietary patterns in the general population.

METHODS AND MATERIALS

Study design and participants

This study comprised three online surveys administered via the "Freeasy" platform operated by iBridge Co., Ltd. : a screening survey, Survey 1, and Survey 2 (Figure 1). The screening survey, conducted from 26 to June 28, 2024, recruited internet users aged 18 years or older and excluded non-Japanese nationals and inattentive respondents using basic demographic questions (e.g., age, sex, residence area, occupation, annual household income, marital status, and number of children) and simple screening questions (e.g., "There are three numbers : 10, 30, and 50. Please choose 30 of these options.").

Survey 1 (1–2 July 2024) was conducted among eligible respondents from the screening survey to assess their habitual dietary behaviors and changes related to emotional states. Survey 2 (September 19 to October 2, 2024) was administered to the same respondents to collect detailed information on specific foods and quantify the magnitude of dietary changes.

The participants were selected to match the national

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population composition ratios by sex and residential area (Supplemental Table 1). All survey company registrants were recruited through an open call. In June 2022, the panel comprised approximately 13 million monitors. An AI-based system automatically detected and excluded inappropriate responses. A total of 2,000, 500 (Table 1), and 200 participants (Supplemental Table 2) were included in the screening survey, Survey 1, and Survey 2, respectively. The study protocol was approved by the Institutional Review Board of the Tokushima University Hospital (approval No. 4528-1). Personal information and privacy were protected according to the policies of both the registered monitor and the research company ; therefore, the participants' information was considered adequately protected. All participants provided informed consent by clicking on the Agreement button before responding.

Data collection

In Survey 1 (n = 500), data were collected on :

(i) Sociodemographic and lifestyle factors (e.g., educational background, smoking habits, drinking habits, physical activity, dietary restrictions, supplement use, and use of nutrition labelling). (ii) Habitual dietary behaviors (e.g., skipping meals, snacking, home cooking, eating out) (iii) the frequency of intake for 19 food groups in the normal state, as well as the extent of change in intake under each emotional state, using a five-point categorical scale ("greatly increased," "slightly increased," "no change," "slightly decreased," and "greatly decreased").

In Survey 2 (n = 200), participants were asked to :

(i) Specify the names of the food items they desire under different emotions and (ii) Rate the degree of change in eating behavior using specific numbers. Responses in Survey 2 (ii) were further quantified by assigning coefficients to each category (1.5 for "greatly increased," 1.2 for "slightly increased," 1.0 for "no change," 0.8 for "slightly decreased," and 0.5 for "greatly decreased," respectively) based on distributional medians (Supplemental Table 3). The habitual frequencies of eating behaviors and food group intake were multiplied by these coefficients to estimate the intake frequency for each emotional state.

Emotions and assessment of eating frequency changes

Emotions were defined based on Ekman's six basic emotions : anger, disgust, fear, happiness, sadness, and surprise (10). In Survey 1, participants reported changes in eating behaviors and the frequency of consumption of 19 food groups for each emotional state compared to their usual calm state. Responses were recorded using a five-point Likert scale ("greatly increased," "slightly increased," "no change," "slightly decreased," and "greatly decreased").

For example, participants were asked, "Compared with your usual calm state, how does your eating behavior change when you feel anger (e.g., when you feel frustrated or things do not go as expected)?" The same format was applied to the other five emotions : disgust (e.g., experiencing unpleasantness or aversion), fear (e.g., feeling anxious or worried), happiness (e.g., feeling happy or excited), sadness (e.g., feeling distressed), and surprise (e.g., experiencing unexpected or startling events).

Assessment of habitual intake frequency of food group and dietary balance score

Habitual intake frequency was assessed for 19 food groups based on the Standard Tables of Food Composition in Japan (8th revised edition), dividing vegetables into green/yellow and

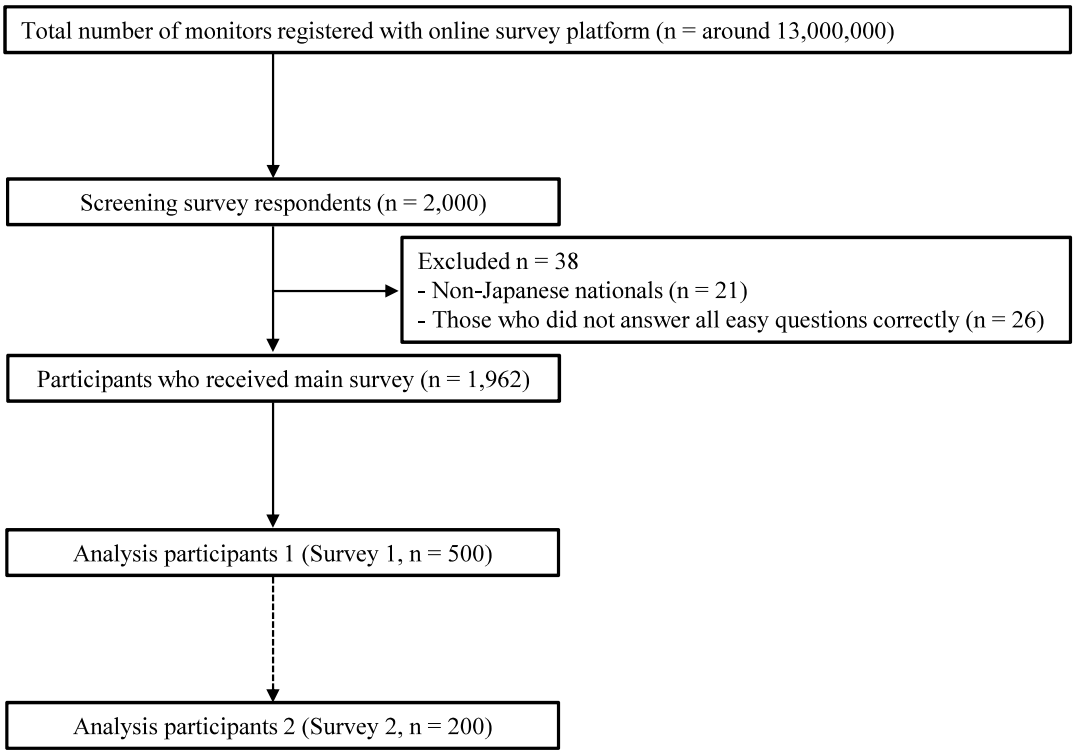

Figure 1. Overview of selected participants
This study consisted of three online surveys conducted on the "Freeasy" platform operated by iBridge Co., Ltd. : a screening survey, Survey 1, and Survey 2. The participants were selected to match the national population composition ratios by sex and residential area. A total of 2,000, 500, and 200 participants were included in the screening, Survey 1, and Survey 2, respectively.

light-colored groups (11). Weekly intake frequencies were calculated from self-reported categories : almost every day (7 times), once every 2 days (3.5 times), once every 3–4 days (2 times), and rarely (0.5). We calculated the intake frequency in each emotional state by multiplying the coefficient from Study 2 (ii) by the intake frequency in the normal state.

Dietary quality was evaluated using the dietary balance score (DBS), which consisted of 10 food groups : fish, seafood, dairy, green/yellow vegetables, light-colored vegetables, meat, legumes, eggs, fruits, mushrooms, and seaweeds. Each group was assigned four, two, one, or zero points, resulting in a total DBS score ranging from 0 to 40, with higher scores indicating better dietary quality (12).

Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD), and means were compared using an independent t-test. Categorical variables were reported as numbers (percentages), and the proportions were compared using the chi-square test.

We examined differences in DBS and its components, expressed as weekly intake frequencies, between the normal and five emotional states using generalized estimating equations (GEE) based on Survey 1 data. First, to assess the association between emotions and diet quality, we specified emotions (normal, anger, disgust, fear, happiness, sadness, and surprise) as the independent variable and DBS or weekly intake frequencies of its components as the dependent variable in the GEE model, with the normal state as the reference category. The adjusted model included the following covariates : age group (≤ 29, 30s, 40s, 50s, 60s, ≥ 70 years), residential area (Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku/Shikoku, Kyushu), annual household income (< 3 million, 3–7 million, 7–12 million, ≥ 12 million yen), and educational background (junior/high/technical high school, vocational/technical college or junior college, university or graduate school, other).

Next, we examined the differences in weekly intake frequencies of confectioneries and beverages between the normal state and the five emotional states using a GEE, adjusting for the same covariates as above, as additional analyses based on

Table 1. Basic characteristics of participants in Survey 1, by sex (n = 500)

		Men (n = 241)	Women (n = 259)	*p*
Age (year) [1,3]		51.2 ± 17.1	51.8 ± 16.6	0.676
Residence area [2,4]	Hokkaido	5 (2.1)	15 (5.8)	0.425
	Tohoku	15 (6.2)	11 (4.2)	
	Kanto	96 (39.8)	99 (38.2)	
	Chubu	37 (15.4)	43 (16.6)	
	Kinki	44 (18.3)	47 (18.1)	
	Chugoku/Shikoku	22 (9.1)	19 (7.3)	
	Kyushu	22 (9.1)	25 (9.7)	
Annual household income [2,4]	Less than 3 million	64 (26.6)	92 (35.5)	0.147
	Three million to less than 7 million	107 (44.4)	98 (37.8)	
	Seven million to less than 12 million	52 (21.6)	55 (21.2)	
	Twelve million or more	18 (7.5)	14 (5.4)	
Marital status [2,4]	Married	120 (49.8)	135 (52.1)	0.602
	Unmarried	121 (50.2)	124 (47.9)	
Number of children [2,4]	One or more	102 (42.3)	123 (47.5)	0.246
	None	139 (57.7)	136 (52.5)	
Educational background [2,4]	Junior high school/high school/vocational high school	98 (40.7)	114 (44.0)	< 0.001
	Vocational university/junior college	11 (4.6)	57 (22.0)	
	University/graduate school	128 (53.1)	86 (33.2)	
	Other	4 (1.7)	2 (0.8)	
Smoking habits [2,4]	Current	75 (31.1)	28 (10.8)	< 0.001
	Former	67 (27.8)	36 (13.9)	
	Never	99 (41.1)	195 (75.3)	
Drinking habits [2,4]	Current	148 (61.4)	112 (43.2)	< 0.001
	Former	26 (10.8)	24 (9.3)	
	Never	67 (27.8)	123 (47.5)	
Physical activity [2,4]	Current	97 (40.2)	94 (36.3)	0.019
	Former	59 (24.5)	44 (17.0)	
	Never	85 (35.3)	121 (46.7)	

[1] Mean ± standard deviation [2] Number (%)
[3] The independent *t*-test was used to calculate the *p* value for continuous variables.
[4] The chi-square test was used to calculate the *p* value for categorical variables.

Survey 1 data. Results are presented as multivariate-adjusted means with 95% confidence intervals in all primary analyses. All the primary analyses were stratified according to sex.

All statistical analyses were performed using IBM SPSS Statistics (version 29.0 ; IBM Japan, Ltd., Tokyo). All p-values < 0.05 were considered statistically significant.

RESULTS

Characteristics of participants

Table 1 presents the characteristics of participants in Survey 1 (n = 500), by sex. The mean age at baseline was 51.2 ± 17.1 years for men and 51.8 ± 16.6 years for women. Men had higher proportions of current smokers, current drinkers, individuals with higher educational backgrounds, and those reporting current physical activity than women did. Age, residential area, annual household income, marital status, and number of children did not differ between the sexes.

Supplemental Table 2 presents the characteristics of participants in Survey 2 (n = 200), by sex. The mean age ± SD at baseline was 51.0 ± 17.0 years for men and 52.0 ± 16.2 years for women. Men had a higher annual household income, a greater proportion of men were current smokers and drinkers, and had higher educational backgrounds than women. Age, residential area, marital status, number of children, and physical activity did not differ between the sexes.

Responses to the question on changes in eating behaviors according to emotion

Figure 2 presents the responses to the question on changes in eating behaviors according to emotion among participants in Survey 1 (n = 500). Over half of the participants (59.6%) reported that emotional states affected food cravings. Additionally, 30.2% indicated that their emotions affect how often they eat, and 47.8% stated that emotional state affects eating habits.

Comparisons of the dietary balance score between normal and non-normal emotional status

Table 2 presents the multivariate-adjusted mean dietary balance scores for each emotional status category, by sex. In both men and women, the multivariate-adjusted means of dietary

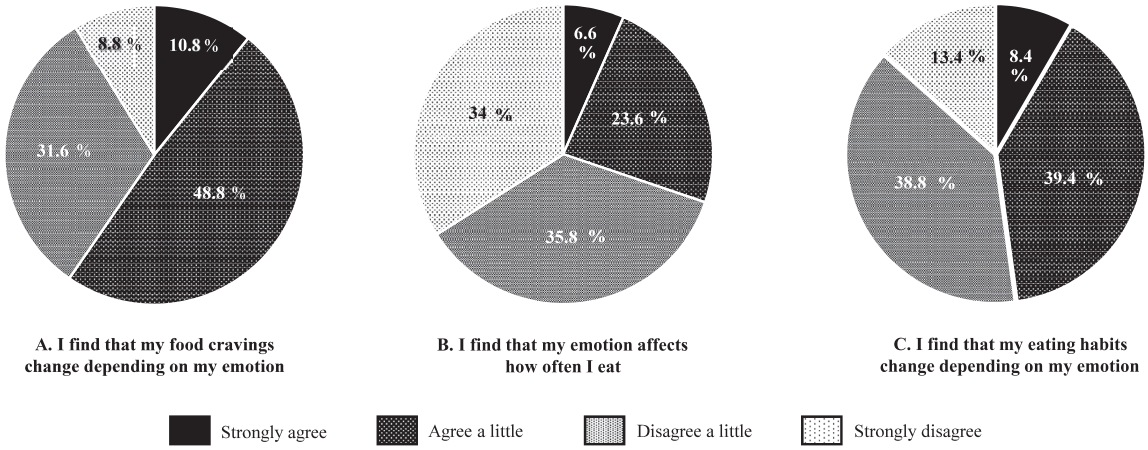

Figure 2. The responses of the question about change in eating behaviors according to emotion
Over half of participants (59.6%) answered that my food cravings changed depending on their emotions (A). Next, one third of participants (30.2%) answered that their emotions affected how often they ate (B). In addition, the half of participants (47.8%) answered that their eating habits changed depending on their emotions (C).

Table 2. The dietary balance score under each emotional state, compared with the normal state, by sex [1,2]

	Men (n = 241)			Women (n = 259)		
	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*
Normal	17.02	(15.21-18.83)	-	20.91	(15.76-26.06)	-
Anger	15.95	(14.18-17.72)	< 0.001	19.86	(14.70-25.01)	< 0.001
Disgust	15.81	(14.05-17.57)	< 0.001	19.61	(14.46-24.77)	< 0.001
Fear	15.23	(13.39-17.08)	< 0.001	18.44	(13.27-23.60)	< 0.001
Happiness	16.70	(14.90-18.49)	0.040	20.70	(15.56-25.84)	0.040
Sadness	14.30	(12.49-16.10)	< 0.001	17.58	(12.41-22.76)	< 0.001
Surprise	16.58	(14.78-18.38)	0.002	20.23	(15.07-25.39)	< 0.001

[1] Generalized estimating equations were used to estimate the adjusted means and 95% CIs of the dietary balance score under each emotional state compared to that under the normal state.
[2] Adjusted model : Adjusted for age (categorical ; 20s and under, 30s, 40s, 50s, 60s, and 70s and over), residence area (categorical ; Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku/Shikoku, and Kyushu), annual household income (categorical ; less than 3 million, 3 million to less than 7 million, 7 million to less than 12 million, and 12 million or more), and educational background (categorical ; junior high school/high school/vocational high school graduate, vocational university/junior college graduate, university/graduate school graduate, and other).
Abbreviations : 95% CI, 95% confidence interval

balance scores decreased in emotionally altered states compared to those in the normal state. The lowest multivariate-adjusted means of dietary balance scores were observed in the sad state for both sexes.

We present the multivariate-adjusted mean weekly intake frequencies of the dietary balance score components for each emotional state, compared with the normal state, in men and women (Tables 3 and 4). In men, all components, except mushrooms, showed lower weekly intake frequencies during sadness than in the normal state. During happiness, weekly intake frequencies of certain components (e.g., dark-green and deep-yellow vegetables, fish, mollusks, crustaceans, meat, eggs, milk, and

Table 3. The weekly intake frequencies of dietary balance score components under each emotional state, compared with the normal state in men (n = 241) [1,2]

	Normal			Anger			Disgust			Fear			Happiness			Sadness			Surprise		
	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*
Pulses	3.13	(2.50-3.76)	-	3.14	(2.50-3.77)	1.000	3.09	(2.45-3.72)	1.000	3.06	(2.42-3.70)	0.546	3.20	(2.56-3.84)	0.051	2.98	(2.35-3.61)	< 0.001	3.13	(2.50-3.77)	1.000
Dark-green and deep-yellow vegetables	3.29	(2.64-3.94)	-	3.26	(2.61-3.91)	1.000	3.23	(2.58-3.88)	1.000	3.15	(2.50-3.80)	0.003	3.38	(2.73-4.04)	0.028	3.05	(2.42-3.69)	< 0.001	3.32	(2.66-3.97)	1.000
Other vegetables	4.18	(3.60-4.76)	-	4.15	(3.57-4.73)	1.000	4.15	(3.57-4.72)	1.000	4.03	(3.45-4.61)	0.007	4.25	(3.67-4.83)	0.148	3.92	(3.35-4.49)	< 0.001	4.25	(3.67-4.83)	0.195
Fruits	2.46	(1.67-3.26)	-	2.48	(1.69-3.28)	1.000	2.48	(1.68-3.27)	1.000	2.41	(1.62-3.21)	1.000	2.54	(1.74-3.33)	0.306	2.36	(1.57-3.15)	0.043	2.52	(1.72-3.32)	0.130
Mushrooms	2.26	(1.89-2.62)	-	2.24	(1.87-2.62)	1.000	2.21	(1.84-2.59)	1.000	2.17	(1.79-2.55)	0.067	2.31	(1.94-2.67)	0.305	2.16	(1.79-2.54)	0.080	2.29	(1.92-2.66)	1.000
Algae	2.72	(2.09-3.34)	-	2.71	(2.08-3.34)	1.000	2.66	(2.04-3.29)	0.179	2.63	(2.00-3.26)	0.054	2.77	(2.15-3.40)	0.543	2.58	(1.95-3.20)	0.001	2.71	(2.08-3.33)	1.000
Fish, mollusks, and crustaceans	2.55	(2.24-2.86)	-	2.50	(2.20-2.81)	0.232	2.50	(2.19-2.81)	0.107	2.49	(2.18-2.80)	0.134	2.63	(2.30-2.95)	0.014	2.38	(2.07-2.69)	< 0.001	2.56	(2.24-2.87)	1.000
Meat	3.22	(2.83-3.61)	-	3.28	(2.88-3.67)	1.000	3.22	(2.83-3.62)	1.000	3.15	(2.75-3.55)	0.486	3.43	(3.03-3.83)	< 0.001	3.01	(2.63-3.40)	< 0.001	3.28	(2.88-3.68)	0.407
Eggs	3.54	(3.00-4.09)	-	3.60	(3.05-4.16)	1.000	3.56	(3.01-4.11)	1.000	3.50	(2.95-4.05)	1.000	3.65	(3.10-4.21)	0.018	3.33	(2.79-3.87)	< 0.001	3.64	(3.08-4.20)	0.026
Milk and milk products	4.10	(3.31-4.90)	-	4.08	(3.28-4.88)	1.000	4.09	(3.29-4.89)	1.000	4.04	(3.24-4.84)	1.000	4.25	(3.46-5.05)	< 0.001	3.90	(3.10-4.70)	< 0.001	4.21	(3.41-5.01)	0.066

[1] Generalized estimating equations were used to estimate the adjusted means and 95% CIs for weekly servings of dietary balance score components under each emotional state compared to those under the normal state. The *p*-values for comparing the frequency of consumption of each food group during each emotional state relative to normal times are shown.
[2] Adjusted model : Adjusted for age (categorical ; 20s and under, 30s, 40s, 50s, 60s, and 70s and over), residence area (categorical ; Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku/Shikoku, and Kyushu), annual household income (categorical ; less than 3 million, 3 million to less than 7 million, 7 million to less than 12 million, and 12 million or more), and educational background (categorical ; junior high school/high school/vocational high school graduate, vocational university/junior college graduate, university/graduate school graduate, and other).
Abbreviations : 95% CI, 95% confidence interval

Table 4. The weekly intake frequencies of dietary balance score components under each emotional state, compared with the normal state in women (n = 259) [1,2]

	Normal			Anger			Disgust			Fear			Happiness			Sadness			Surprise		
	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*
Pulses	3.83	(2.76-4.90)	-	3.82	(2.75-4.89)	1.000	3.80	(2.73-4.86)	1.000	3.68	(2.61-4.74)	0.004	3.87	(2.80-4.94)	1.000	3.60	(2.53-4.67)	< 0.001	3.80	(2.73-4.87)	1.000
Dark-green and deep-yellow vegetables	4.52	(3.45-5.59)	-	4.49	(3.41-5.56)	1.000	4.45	(3.38-5.53)	1.000	4.33	(3.26-5.41)	0.001	4.62	(3.55-5.70)	0.007	4.22	(3.15-5.29)	< 0.001	4.52	(3.44-5.59)	1.000
Other vegetables	4.87	(3.81-5.94)	-	4.83	(3.75-5.90)	1.000	4.80	(3.72-5.87)	1.000	4.66	(3.59-5.73)	< 0.001	5.00	(3.93-6.07)	0.001	4.59	(3.52-5.66)	< 0.001	4.85	(3.78-5.92)	1.000
Fruits	3.57	(2.74-4.40)	-	3.60	(2.77-4.43)	1.000	3.54	(2.71-4.37)	1.000	3.47	(2.64-4.29)	0.190	3.71	(2.88-4.55)	0.001	3.38	(2.56-4.21)	0.001	3.54	(2.71-4.37)	1.000
Mushrooms	3.19	(2.31-4.07)	-	3.19	(2.32-4.07)	1.000	3.17	(2.29-4.05)	1.000	3.08	(2.20-3.96)	0.005	3.26	(2.38-4.14)	0.014	3.03	(2.15-3.91)	0.002	3.19	(2.31-4.07)	1.000
Algae	3.06	(2.05-4.08)	-	3.06	(2.05-4.07)	1.000	3.02	(2.01-4.04)	1.000	2.95	(1.94-3.95)	0.016	3.09	(2.08-4.11)	1.000	2.93	(1.92-3.95)	0.006	3.07	(2.05-4.08)	1.000
Fish, mollusks, and crustaceans	2.65	(2.18-3.13)	-	2.64	(2.16-3.11)	1.000	2.60	(2.13-3.07)	0.716	2.53	(2.05-3.00)	< 0.001	2.72	(2.25-3.20)	0.005	2.47	(2.00-2.95)	< 0.001	2.65	(2.17-3.12)	1.000
Meat	3.98	(2.91-5.06)	-	4.13	(3.05-5.20)	0.008	3.95	(2.88-5.03)	1.000	3.82	(2.75-4.90)	0.006	4.17	(3.10-5.25)	< 0.001	3.68	(2.61-4.75)	< 0.001	3.99	(2.92-5.06)	1.000
Eggs	4.20	(3.11-5.28)	-	4.22	(3.13-5.30)	1.000	4.18	(3.10-5.27)	1.000	4.08	(2.99-5.17)	0.012	4.26	(3.17-5.34)	0.271	4.00	(2.91-5.08)	< 0.001	4.20	(3.11-5.29)	1.000
Milk and milk products	4.18	(3.55-4.81)	-	4.24	(3.60-4.87)	1.000	4.19	(3.56-4.83)	1.000	4.06	(3.43-4.70)	0.271	4.32	(3.68-4.95)	0.014	3.91	(3.28-4.54)	< 0.001	4.17	(3.54-4.80)	1.000

[1] Generalized estimating equations were used to estimate the adjusted means and 95% CIs of the number of servings per week of dietary balance score components under each emotional state compared to those under the normal state. The *p*-values for comparing the frequency of consumption of each food group during each emotional state relative to normal times are shown.
[2] Adjusted model : Adjusted for age (categorical ; 20s and under, 30s, 40s, 50s, 60s, and 70s and over), residence area (categorical ; Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku/Shikoku, and Kyushu), annual household income (categorical ; less than 3 million, 3 million to less than 7 million, 7 million to less than 12 million, and 12 million or more), and educational background (categorical ; junior high school/high school/vocational high school graduate, vocational university/junior college graduate, university/graduate school graduate, and other).
Abbreviation ; 95% CI, 95% confidence interval

milk products) increased compared with the normal state. In women, weekly intake frequencies of all components decreased during sadness compared to the normal state. Additionally, during fear, the intake frequencies of some components (e.g., pulses, dark-green and deep-yellow vegetables, other vegetables, mushrooms, algae, fish, mollusks, crustaceans, meat, and eggs) decreased compared to the normal state. During happiness, the intake frequencies of some components (e.g., dark-green and deep-yellow vegetables, other vegetables, fruits, mushrooms, fish, mollusks, crustaceans, meat, milk, and milk products) increased compared to the normal state.

Comparisons of the weekly intake frequencies of confectionery and beverages between normal and emotionally altered states

To clarify which foods participants (n = 200) associated with emotionally altered states compared to normal states, we reviewed their free-form responses regarding meal contents. Over 30% of female respondents (n = 104) reported craving confectionery when feeling angry (69), disgusted (47), fearful (38), happy (57), sad (31), or surprised (51). For all emotions, sweet confectionery (e.g., cakes, chocolate, and ice cream) was the most frequently cited : 58 cited it for anger, 42 for disgust, 35 for fear, 56 for happiness, 27 for sadness, and 50 for surprise. In contrast, over 30% of male respondents (n = 96) reported not eating anything in emotionally altered states compared to normal states.

We compared weekly intake frequencies of confectioneries and beverages in each emotional state with those in the normal state, by sex (Table 5). For both men and women, weekly intake frequency of confectionery decreased during sadness and increased during happiness. Weekly intake frequencies of beverages increased happiness, anger, and disgust. Among men, weekly intake frequency of beverage increased during surprises, whereas among women, confectionery increased during anger and disgust.

DISCUSSION

This study examined how transient emotional states affect dietary behavior. DBS generally decreased under all emotional states compared to the normal state in both sexes (Table 2). Weekly intake frequency of DBS component foods decreased sadness and increased happiness (Tables 3 and 4). This change differed by sex ; men showed relatively smaller changes, whereas women exhibited broader changes. The weekly intake frequencies of discretionary foods also varied by emotion and sex ; weekly intake frequency of confectionery increased during happiness and decreased during sadness (Table 5), particularly in women, whereas many men reported no change. These findings indicate that emotional state influences dietary behavior and food group intake frequencies in a sex-specific manner, with women showing greater variability across emotions.

Our finding that emotional arousal alters diet quality and food group intake frequencies aligns with previous literature reporting emotion-linked changes in eating behaviors. Experimental and observational studies have shown that stress and negative affect are often associated with increased intake of energy-dense "comfort" foods. At the same time, positive affect can also increase intake in some contexts (13-15). Systematic reviews and meta-analyses indicate that stress and negative emotions tend to decrease healthy food consumption and increase unhealthy food intake. However, these effects are heterogeneous and moderated by individual differences such as restrained or emotional eating (16, 17). Recent reviews and systematic studies have shown that emotional eating often involves hyperpalatable, energy-dense foods, and positive emotions can contribute to higher caloric intake in certain populations (18). Several studies have also documented sex differences in emotion-related eating, with women typically showing greater susceptibility to emotion-driven changes in food choices than men (19). These findings support

Table 5. The weekly intake frequencies of confectionery and beverages under each emotional state, compared with the normal state, by sex [1,2]

		Men (n = 241)			Women (n = 259)		
		Adjusted mean	95% CI	*p*	Adjusted mean	95% CI	*p*
Confectionery	Normal	2.55	(2.06-3.03)	-	3.13	(1.99-4.28)	-
	Anger	2.64	(2.14-3.13)	0.291	3.66	(2.51-4.82)	< 0.001
	Disgust	2.61	(2.12-3.09)	1.000	3.49	(2.34-4.65)	< 0.001
	Fear	2.52	(2.03-3.01)	1.000	3.05	(1.91-4.20)	1.000
	Happiness	2.78	(2.29-3.26)	< 0.001	3.61	(2.46-4.75)	< 0.001
	Sadness	2.42	(1.92-2.92)	0.011	2.88	(1.74-4.02)	0.001
	Surprise	2.62	(2.12-3.11)	0.203	3.24	(2.10-4.37)	0.066
Beverages	Normal	4.35	(3.61-5.09)	-	4.44	(3.61-5.26)	-
	Anger	4.57	(3.82-5.32)	0.003	4.87	(4.02-5.72)	< 0.001
	Disgust	4.53	(3.78-5.27)	0.003	4.74	(3.90-5.58)	< 0.001
	Fear	4.40	(3.66-5.15)	1.000	4.45	(3.61-5.29)	1.000
	Happiness	4.78	(4.03-5.54)	< 0.001	4.90	(4.06-5.74)	< 0.001
	Sadness	4.22	(3.48-4.96)	0.390	4.28	(3.45-5.11)	0.556
	Surprise	4.48	(3.73-5.22)	0.003	4.51	(3.67-5.34)	1.000

[1] Generalized estimating equations were used to estimate the adjusted means and 95% CIs of the number of servings per week of confectionery and beverages under each emotional state compared to that under the normal state.
[2] Adjusted model : Adjusted for age (categorical ; 20s and under, 30s, 40s, 50s, 60s, and 70s and over), residence area (categorical ; Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku/Shikoku, and Kyushu), annual household income (categorical ; less than 3 million, 3 million to less than 7 million, 7 million to less than 12 million, and 12 million or more), and educational background (categorical ; junior high school/high school/vocational high school graduate, vocational university/junior college graduate, university/graduate school graduate, and other).
Abbreviations : 95% CI, 95% confidence interval

our observation of decreased dietary balance under emotional states and sex-specific patterns of food group changes.

Several biological and psychological mechanisms may underlie the observed associations between emotions and dietary behavior. Stress and its negative effects activate the hypothalamic–pituitary–adrenal (HPA) axis, leading to cortisol release, which has been linked to an increased intake of palatable, energy-dense foods (20, 21). Dopaminergic reward pathways are also involved in emotion-driven eating, and emotional arousal can enhance the reward properties of foods high in sugar and fat (22, 23). Cognitive and self-regulatory processes also contribute, because negative emotions may impair prefrontal executive function and reduce inhibitory control, which facilitates overeating (24). Furthermore, sex differences in emotion-related eating may be partly due to hormonal influences (e.g., estrogen and progesterone) and to coping styles, with women more likely to use food as an emotion-regulation strategy (25, 26). Especially, one of the sex hormones, estrogen, has been hypothesized to exert anorexigenic effects during the follicular phase of the menstrual cycle. At the same time, progesterone may enhance appetite in the luteal phase (27, 28). Moreover, cyclical decreases in estradiol and fluctuations in progesterone and its neuroactive metabolites (e.g., allopregnanolone) have been reported to correlate with emotional and reward-driven eating behaviors (29). Together, these mechanisms provide a plausible explanation for the emotion- and sex-specific patterns of dietary balance observed in our study.

These findings have practical implications for public health and clinical practice. Emotion-related changes in diet quality may contribute to obesity and metabolic disorders, highlighting the importance of addressing emotional states during dietary interventions (30, 31). Because women show greater variability in dietary responses, emotion regulation training that decreases stress levels may help mitigate emotional eating and promote healthier choices (32). Other intervention approaches address eating behaviors in positive emotional states, such as happiness. Potential intervention strategies to maintain self-regulation during positive emotional states may include emotion labelling and monitoring (e.g., recognising that the urge to eat is driven by positive emotion rather than hunger) (33, 34), mindful eating (e.g., eating with awareness of internal cues despite emotional excitement) (35, 36), reward-substitution behaviors (e.g., engaging in pleasant non-food activities) (37), and habit-based "if–then" action plans that provide alternative responses (e.g., drinking water or taking deep breaths) to heightened positive emotion (38). Such potential interventional approaches should be incorporated into nutritional guidance and preventive strategies according to emotional context, emphasizing both dietary education and psychological support to improve long-term diet quality and health outcomes.

This study has several strengths. This was based on a well-established theoretical framework of basic emotions. We assessed both habitual dietary behaviors and diet quality using validated indices, enabling a comprehensive evaluation of emotional influences on eating patterns. However, this study has several limitations. First, its cross-sectional design precludes causal inferences. Future studies should use longitudinal or experimental designs to clarify the causal relationships between emotions and dietary behaviors. Second, the dietary data were self-reported and may have been subject to recall or social desirability bias (39, 40). Third, although the sampling reflected population ratios from demographic statistics, participants were recruited from an online panel in Japan, which may limit the generalizability of the findings to other populations. Fourth, the estimation of weekly intake frequencies of food group under emotional states relied on self-rated coefficients, which may not fully reflect the actual changes in consumption. Finally, we could not obtain biological factors such as sleep status or stressors that might have influenced the observed associations. In the future, integrating physiological measures such as biomarkers of stress or neural correlations of reward processing may help clarify the underlying mechanisms.

In conclusion, transient emotional states are associated with changes in dietary balance and food group consumption, with women exhibiting greater variability across emotions than men. Interventions tailored to gender differences in emotion-driven eating may contribute to more effective dietary guidance and mental health support. These findings highlight the importance of considering emotional context in dietary research and suggest that both nutrition education and mental health interventions should address the relationship between mood and eating behaviors.

CONFLICT OF INTEREST

The authors have no relevant financial or nonfinancial interests to disclose.

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AUTHORS' CONTRIBUTIONS

All the authors (M. N., S. K., A. O., H. K., A. N., and T. S.) developed the study. M. N. and S. K. collected the data. The measurements and data analyses were performed by M. N., and S. K.. A. N., and T. S. provided nutritional advice for data interpretation. M. N. drafted the manuscript with assistance from T. S.. All the authors have read and approved the final version of this manuscript.

ETHICAL APPROVAL

The study was conducted according to the ethical standards of the Declaration of Helsinki, and the protocol was approved by the institutional review board of Tokushima University Hospital (ethical approval No. 4528-1).

CONSENT

Informed consent was obtained electronically from all participants.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed in the current study are available from the corresponding author upon reasonable request.

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Supplemental Table 1. Population composition ratio [1,2,3]

	National		Present study	
	Men (n = 48,847)	Women (n = 52,717)	Men (n = 241)	Women (n = 259)
20s and under	5,965 (12.2)	5,701 (10.8)	39 (16.2)	38 (14.7)
30s	6,405 (13.1)	6,156 (11.7)	34 (14.1)	32 (12.4)
40s	8,199 (16.8)	7,929 (15.0)	39 (16.2)	38 (14.7)
50s	8,972 (18.4)	8,809 (16.7)	41 (17.0)	41 (15.8)
60s	7,194 (14.7)	7,418 (14.1)	48 (19.9)	76 (29.3)
70s and over	12,112 (24.8)	16,704 (31.7)	40 (16.6)	34 (13.1)

[1] Number (%)
[2] The national data were based on the "Overview of the results of the 2024 population estimates" by the Statistics Bureau of the Ministry of Internal Affairs and Communications.
[3] The numbers for national data by gender and age group are shown for the population aged 20 and over.

Supplemental Table 2. Basic characteristics of participants in Survey 2, by sex (n = 200)

		Men (n = 96)	Women (n = 104)	*p*
Age (year) [1,3]		51.0 ± 17.0	52.0 ± 16.2	0.689
Residence area [2,4]	Hokkaido	4 (4.2)	7 (6.7)	0.785
	Tohoku	2 (2.1)	0 (0.0)	
	Kanto	40 (41.7)	44 (42.3)	
	Chubu	12 (12.5)	15 (14.4)	
	Kinki	19 (19.8)	19 (18.3)	
	Chugoku/Shikoku	7 (7.3)	9 (8.7)	
	Kyushu	12 (12.5)	10 (9.6)	
Annual household income [2,4]	Less than 3 million	19 (19.8)	40 (38.5)	0.022
	Three million to less than 7 million	50 (52.1)	36 (34.6)	
	Seven million to less than 12 million	19 (19.8)	21 (20.2)	
	Twelve million or more	8 (8.3)	7 (6.7)	
Marital status [2,4]	Married	45 (46.9)	49 (47.1)	0.973
	Unmarried	51 (53.1)	55 (52.9)	
Number of children [2,4]	One and over	42 (43.8)	40 (38.5)	0.447
	None	54 (56.3)	64 (61.5)	
Educational background [2,4]	Junior high school/high school/vocational high school	33 (13.7)	39 (15.1)	< 0.001
	Vocational university/junior college	2 (0.8)	24 (9.3)	
	University/graduate school	60 (24.9)	40 (15.4)	
	Other	1 (0.4)	1 (0.4)	
Smoking habits [2,4]	Current	24 (10.0)	14 (5.4)	0.009
	Never	49 (20.3)	75 (29.0)	
	Former	23 (9.5)	15 (5.8)	
Drinking habits [2,4]	Current	63 (26.1)	53 (20.5)	0.054
	Never	25 (10.4)	44 (17.0)	
	Former	8 (3.3)	7 (2.7)	
Physical activity [2,4]	Current	43 (17.8)	36 (13.9)	0.234
	Never	31 (12.9)	45 (17.4)	
	Former	22 (9.1)	23 (8.9)	

[1] Mean ± standard deviation [2] Number (%)
[3] The independent *t*-test was used to calculate the *p* value for continuous variables.
[4] The chi-square test was used to calculate the *p* value for categorical variables.

Supplemental Table 3. Responses regarding the extent to which eating habits changed when emotionally unstable compared to normal (n = 200)

	Median	(25th percentile, 75th percentile)
Degree reflecting "greatly increased"	1.5	(1.5 , 2)
Degree reflecting "slightly increased"	1.2	(1.1 , 1.5)
Degree reflecting "slightly decreased"	0.8	(0.5 , 0.8)
Degree reflecting "greatly decreased"	0.5	(0.5 , 0.6)

This table shows responses to the following question : How much do you change your food intake when your emotions change compared to normal? The results show the median, 25th percentile, and 75th percentile of the responses.